Injuries and Surgical Diseases of the Ischium

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DEDICATED TO THE BELOVED MEMORY OF MY FATHER

JACOB VICTOR MILCH

1866–1945

Contents

Preface

F THE THREE components that unite to form the os innominatum, the chium has special significance that warrants detailed study While all ree portions of the bone exhibit an essentially similar response to various athological processes, their clinical manifestations are frequently different.

The significant distinction lies in the fact that involvement of the ilium r pubis is usually manifested by *localized* signs and symptoms, which ren er diagnosis relatively simple, while identical pathological processes in the chium may first betray their existence by more *diffuse* symptomatology ich as a coxalgia or a sciatica, which may arouse the erroneous suspicion f disease located either in the hip joint or in the lumbar spine. Indeed both 1 the child and the adult, the ischium may be the site of typical disease rocesses that simulate affections of the hip characteristically seen in specific ge groups. As a consequence critical evaluation of the symptomatology pparently arising in either the hip or the lower spinal region is impossible without conscious exclusion of the ischium and, to a lesser degree, of the acrum as the site of abnormality

It is for the purpose of redirecting attention to these conditions that the following text has been prepared References to the literature are not pre sented as a bibliography of the various subjects but rather as a list of the more significant contributions that may be consulted.

The author expresses his grateful thanks to Mrs. B Lindemann for her tireless constancy in the preparation of the manuscript. He acknowledges with warmest thanks the painstaking labors of Mrs. June M Dubovsky in preparing illustrations of high quality and precise clarity the seemingly endless efforts of Dr Robert Austin Milch in both preparation and editing of the manuscript, and, most especially the constant stimulation and counsel of his wife who so enthusiastically performed the monotonous and unre warding task of proofreading

His thanks, too are due the authors of texts and the editors of various

journals for their kind permission to reprint here items from their works. Finally the author wishes to express his very deep gratitude to Mr Paul H. Hoeber and Mrs. Eunice Stevens, his editor for the courtesies and kind cooperation shown him during the preparation and publication of this work.

H M.

New York

INJURIES AND SURGICAL DISEASES OF THE ISCHIUM

CHAPTER 1

Anatomy of the Ischium

THE NAME "ISCHIUM" is derived from the Greek, meaning "to support in the seated position." In the older French literature, the ischium is designated as "os à l'assiètte" and in modern German it is still called "Sitzbein," in recognition of the fact that the body weight is largely supported by the two ischial tuberosities in the seated position.

In the baboon, which habitually assumes the seated posture the tuberosity of the ischium is correspondingly broader and thicker than in animals not characterized by sitting In humans as well as in the lower forms, the ischium forms a large part of the lateral wall of the true pelvis. It is one of three bones that enter into the formation of the acetabulum, and is the only one of the three bones, the ilium, the ischium, and the pubis, which is constantly represented in the formation of the acetabular cavity throughout the evolution of the locomotor apparatus and the concomitant developmental history of the pelvic girdle. From its widespread presence, it is evident that the ischium developed to subserve both the need of sitting and that of locomotion.

In the early free-swimming vertebrates, pelvic fins, the homologues of the lower extremities, develop from a primitive stabilizing mechanism, the lateral folds. To afford a stable support for the action of these structures, basal elements of the appendages were modified and the pelvic girdle was developed. Romer[11] notes that "in fishes, each half of the girdle is a small, simple ventral plate, often triangular embedded in the muscles and connective tissue of the abdomen, typically just anterior to the cloaca." Anteriorly the two plates make contact, but posteriorly there is no contact with the axial skeleton (Fig 1*A*) "In the process of tetrapod development, the original ventral girdle on either side becomes a large plate of bone lying in a tilted position in the flank This ossifies from two centers, the pubis anteriorly and the ischium posteriorly and may be termed the pubo-ischiadic plate (Fig 1*B*)

In the later amphibians, the ilium develops posteriorly and attaches first to one sacral rib and later to several (Fig 1C)

During the course of evolution, the pelvic girdle undergoes many variations. In some, as in the birds, the pubic symphysis is lost entirely In others, as in the crocodile and the alligator the pubis is completely excluded from

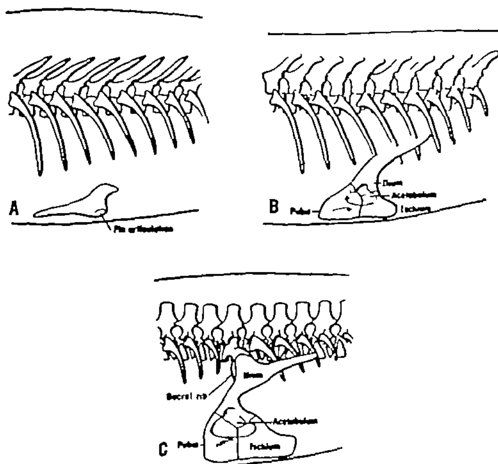


FIG. 1 Lateral diagrams showing the development of the pelvic girdle from fish to the amphibia *A*, fish. The ventrally situated pelvic girdle is developed entirely in the lateral musculature of the abdominal wall. *B* primitive tetrapod stage in the fossil amphibians. The ilium represented by a long posteriorly directed spike makes contact with the transverse process of one or more vertebrae. *C* amphibian. The ilium has broadened and has made firm contact with the vertebrae. (Reproduced from Romer A. S *The Vertebrate Body* Philadelphia and London, W B. Saunders Co 1949)

participation in the formation of the acetabular cavity by overgrowth of the ischium. Despite these changes, the persistence of the ischium in all forms is evidence of its importance in the statics and dynamics of the lower extremity in relation to which it originally developed.

In man, the cartilaginous anlage of the ischium appears during the second month of fetal life and chondrification is completed during the third month.

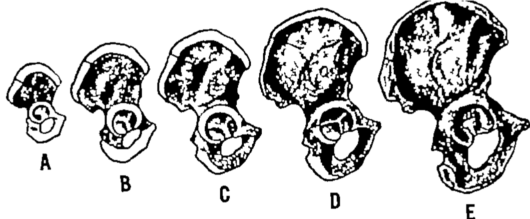


FIG. 2. Ossification of the innominate bone. *A*, at the third intrauterine month; *B*, at birth; *C*, during the first year; *D*, at six years of age; *E*, at about fifteen years of age. (Reproduced from Piersol, G. A. *Human Anatomy*. Philadelphia and London, J. B. Lippincott Co., 1906.)

At this time, the primary center of ossification for the ischium appears in the body of the bone. Secondary centers of ossification for the acetabulum appear some time before the tenth year but secondary centers for the ischial spine and the tuberosity do not become roentgenographically apparent before the age of eleven. Ossification in the body progresses so that at about the age of eight the epiphysis between the ischial ramus and the descending ramus of the pubis normally closes. Complete ossification and union of the acetabular centers occurs at about the age of fifteen, but the epiphysis of the tuberosity does not fuse solidly until about the twentieth year (Fig. 2).

The epiphysis of the ischial tuberosity has been described by Poland[19] as a "wide and thick plate wider



FIG. 3. Secondary centers of ossification of the os innominatum. The centers of ossification of the iliac crest, the posterior iliac spine, the anterior inferior spine of the ilium, the ischial spine, and the ischial tuberosity are shown. The forward prolongation of the apophysis of the tuberosity indicates the line of attachment of the falciform portion of the sacrotuberous ligament. (Reproduced from Hellmer, H., A case of traumatic separation of the epiphysis of the ischium. *Arch. Orthopedie u. Unfallkrankheiten*, 43: 45, 1933.)

than any of the other epiphyses of the hip bone. It extends from the lesser sacro-sciatic notch to the upper end of the descending ramus of the pubis." Hellmer[7] states that "the epiphysis includes not only the tuber ischii but extends forward to the junction with the os pubis, which is interesting from the phylogenetic point of view Parsons thinks that the epiphysis of the ischium is homologous with the hypoischium of reptiles" (Fig 3)

THE ADULT ISCHIUM

The adult ischium, the thickest and stoutest part of the os innomi natum, consists of (1) the body (2) the ramus, and (3) the tuberosity (Fig 4)

The *body* on cross section is somewhat triangular in outline with its apex directed outward. It presents three surfaces (anteroexternal, posteroexternal, and internal) and three borders (anterior posterior external) The *antero-*

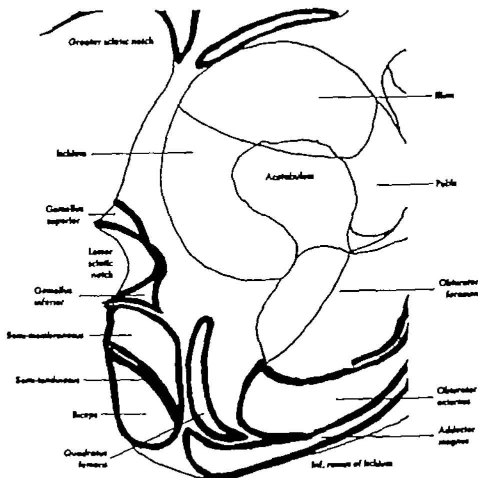


Fig. 4 Lateral view of muscular attachments to the surfaces of the ischium. (*After* Gray, H *Human Anatomy* Spitzka, Philadelphia, and New York, Lea & Febiger 1913.)

external surface is bounded anteriorly by the anterior border and posteriorly by the external border Above, this surface corresponds largely to the ischial component of the acetabular cavity It is smooth, concave, and partly covered with cartilage for articulation with the head of the femur Below the acetabulum and just above the external surface of the tuberosity with which the anteroexternal surface of the body is continuous, there is a groove along which the tendon of the obturator externus muscle glides as it passes backward to be inserted into the trochanteric fossa of the femur

The *posteroexternal surface* is bounded anteriorly by the external border and posteriorly by the posterior border Above, it is continuous with the ilium and below with the ischial tuberosity It is broad smooth and somewhat quadrilateral in shape and provides the surface over which the pyriformis, the gemelli superior and inferior and the obturator internus muscles glide as they pass out of the pelvis to their insertion in the trochanteric fossa of the femur The lower portion of this surface presents the continuation of

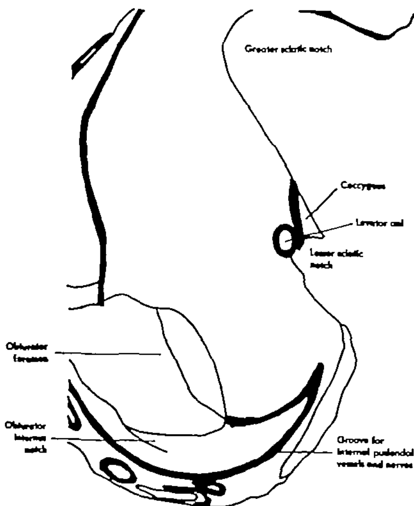


FIG. 4B Medial view of muscular attachments to the surfaces of the ischium. (*After* Gray H *Human Anatomy* Spitzka, Philadelphia, and New York, Lea & Febiger 1913)

the groove for the obturator externus tendon seen on the anteroexternal surface The inferior edge of this groove is formed by the projection of the tuberosity and is the site of origin of the gemellus inferior muscle.

The *internal surface*, which forms part of the lateral wall of the true pelvis, is smooth, concave, and affords attachment to a part of the obturator internus muscle.

The *anterior border* forms part of the outer circumference of the obturator foramen. The *external border* separates the anteroexternal from the posteroexternal surfaces of the body The *posterior border* of the body of the ischium is continuous with the posterior border of the ilium and forms the larger part of the anterior circumference of the great sacrosciatic notch. Somewhat below the mid point of the posterior border of the ischium, a thin, triangular prominence of bone the *spine of the ischium*, projects posteriorly and medially The outer surface of the spine is the site of origin of the gemellus superior muscle its inner surface is the site of origin of the coccygeus and part of the levator ani muscles, while its apex gives attachment to the sacrospinous or lesser sacrosciatic ligament Below the ischial spine, on the posterior border of the bone is a notch that transmits the tendon of the obturator internus muscle. This notch is converted into a foramen, the lesser sacrosciatic foramen, by the attachment of the sacrospinous ligament to the spine above and of the sacrotuberous ligament to the tuberosity below

The *ramus* is continuous with the tuberosity and is considerably stouter than the descending ramus of the pubis, which it runs inward and upward to meet to complete the ischiopubic arch. This portion of the bone is flattened and presents two surfaces and two borders. The *outer surface* is rough and gives origin to part of the obturator externus and adductor magnus muscles. Its *inner surface* is smooth and forms part of the outer wall of the true pelvis. The *upper border* is thin and sharp and forms part of the lower circumference of the obturator foramen The *inferior border* is thick and rough and presents two edges with an intervening space. The superficial layer of the triangular ligament of the perineum is attached to the inner edge of the inferior border The deep layer of the superficial perineal fascia is attached to the outer edge. The transversus perinei and the erector penis or erector clitoridis muscles take their origin from the surface between these two edges.

The *tuberosity* of the ischium is that portion of the bone between the body and the ramus. On cross section it, like the body is triangular in outline with the apex of the triangle directed outward. It presents three surfaces and three borders. The apex, formed by the external border is collinear with the external border of the body and divides the external from the posterior surfaces of the tuberosity

The *external surface* of the tuberosity is somewhat quadrilateral in outline and is continuous with the body above and with the ramus below. It is bounded in front by its anterior border which forms part of the posterior and inferior margin of the obturator foramen, and behind by the external border which separates the external from the posterior surfaces of the tuberosity. It gives origin to the quadratus femoris muscle and in front of this to some fibers of the obturator externus and adductor magnus muscles.

The *internal surface* is bounded anteriorly by the posterior margin of the obturator foramen and posteriorly by the posterior border to which the falciform prolongation of the sacrotuberous ligament is attached.

The *posterior surface* is quadrilateral in shape and is bounded above by the groove for the tendon of the obturator internus muscle, laterally by the external border and medially by the posterior border. It is divided into an upper and a lower part. The inferior part, triangular in shape, is subdivided into two smaller parts by a prominent vertical ridge. The outer of these subdivisions is rough and serves for the origin of the posterior fibers of the adductor magnus muscle. The inner subdivision serves for the attachment of the sacrotuberous ligament. The superior of the two main divisions is quadrilateral in outline and is, in turn, subdivided by an oblique ridge into an upper outer portion that affords attachment to the origin of the semimembranosus muscle and a lower inner portion that gives rise to the semitendinosus and biceps femoris muscles.

Two ligaments are particular to the ischium: the sacrotuberous or great sacrosciatic ligament and the sacrospinous or lesser sacrosciatic ligament (Fig. 5). These two ligaments serve to convert the notch on the posterior border of the body into a foramen, the lesser sacrosciatic foramen, which transmits the tendon of the obturator internus muscle. In addition, it transmits the internal pudendal vessels that make their exit from the pelvis through the great sacrosciatic foramen above the levator ani muscle, wind around the base of the ischial spine, and re-enter the pelvis through the lesser sacrosciatic foramen below the levator ani muscle.

The sacrotuberous or greater sacrosciatic ligament is flat and is narrower in its mid portion than at either extremity. It arises from the broad base afforded by the posterior spine of the ilium and the lower part of the lateral margin of the sacrum. It passes obliquely downward, forward and outward to be attached along the inner margin of the tuberosity and, by its falciform prolongation, to the inner edge of the ramus of the ischium. Among others, Piersol* has called attention to the fact that, at its insertion into the tuberosity, the ligament "is continuous with the fibres of origin of the biceps." This is especially interesting in view of the homology that has been established between the human biceps femoris and the hamstring muscles of lower forms, the sacroperonealis and the iliopercnealis muscles. In these lower

forms, the hamstring muscles attach either to the sacrum or the ilium and act with other muscles that tend to tilt the pelvis upward.

Bland Sutton[14] has noted that in man, "the biceps femoris tendon arises from the tuberosity of the ischium but when its tendon of origin is carefully dissected, it can be traced into the great sacro-sciatic ligament. By pulling on the hamstring muscles and especially the biceps, the coccyx may be made to move on the sacrum." He noted further that "Weber found in a subject dissected at Guy's Hospital, a sesamoid in the tendon of the biceps and this tendon, which was directly continuous with the great sacro-sciatic ligament, glided over but had no attachment to the ischial tuberosity. The conclusion is irresistible that the great sacro-sciatic ligament is the divorced tendon of the biceps femoris muscle."



FIG. 5 The posterior ligaments of the sacroiliac articulation *A*, the sacrotuberous ligament showing its falciform prolongation *B* the spinous attachment of the sacrospinous ligament. (Reproduced from Rouviere, H *Anatomie Humaine* Masson et Cie, Paris, 1924.)

The *sacrospinous* or lesser sacrosciatic *ligament* is much smaller than the sacrotuberous ligament. It is fan-shaped in outline and arises from a broad base on the lateral margin of the sacrum and coccyx, anterior to the origin of the sacrotuberous ligament. It courses downward and outward and is attached by its apex to the tip of the ischial spine. Though its function in adult anatomy seems to be that of re-enforcing the stabilizing action of the sacrotuberous ligament, its derivation appears to be entirely

different. Bland Sutton,[18] who originally expressed the opinion that it represented the regressive remnant of an earlier osseous union between the ischial spine and the sacrum, later concluded that 'the coccygeus is, in man, a vestigial muscle and a superficial examination is sufficient to show that it contains a large amount of fibrous tissue A study of comparative anatomy of muscles demonstrates satisfactorily that the lesser sarco-sciatic ligament results from regression of a large tract of the coccygeus. In the first edition of this book, I regarded the lesser sacro-sciatic ligament as the fibrous representation of the long ischial spine which in armadillos sloths and other edentata, recent or extinct, reaches to the side of the pseudo-sacral vertebrae. The view that the coccygeus is responsible for it is simpler and more probable.

A number of different *bursae*, by some alleged to be inconstant, have been described in relation to the ischium. The largest of these, when present, the bursa ischiadica, is situated between the deep surface of the gluteus maximus and the tuberosity of the ischium This bursa is not be confused with the occasionally present *subcutaneous bursa tuberis ischiadica* described by Vulpian and Hyrtl. Another the *bursa musculi obturatori interni*, probably more constant but clinically less important, is described as existing between the tendon of the obturator internus and the margin of the great sacrosciatic notch over which the muscle passes Several smaller muscular bursae exist between the origins of the semimembranosus and semitendinosus muscles.

The *arterial* supply and especially the *venous* drainage of the ischium are of great interest and importance. The main artery of the ischium and the surrounding region, the obturator artery is extremely variable in origin. In about half the cases, it arises from the anterior division of the internal iliac or hypogastric artery It may however arise from the common iliac, the internal pudendal, the sciatic, or the gluteal artery In other instances, it has been described as arising from the external iliac, the deep epigastric, or even the femoral artery Within the pelvis, the obturator artery gives off three branches a pubic, a vesical, and an iliac branch The artery makes its exit from the pelvis through the obturator canal Just before it leaves the canal it divides into anterior or internal and posterior or external branches that lie between the obturator membrane and the obturator externus muscle and diverge at almost ninety degrees from each other The anterior branch follows the anterior outline of the obturator membrane and supplies the pubis and the muscles that arise from the pubis. The posterior branch, lying mainly along the posterior rim of the obturator membrane sends a branch through the incisura acetabuli to supply the fat and ligamentum teres of the acetabular cavity and then descends to terminate around the ischial tuberosity

Waldeyer [14] who made a special study of the terminal distribution of the obturator artery noted that in fifty cases he invariably found an additional long branch that descended on the *inner* surface of the obturator membrane to supply the tuberosity of the ischium. This small artery is a branch of the posterior division of the obturator artery that should properly be described as dividing into three branches (1) an acetabular branch supplying the acetabular cavity (2) an internal branch, which descends along the inner

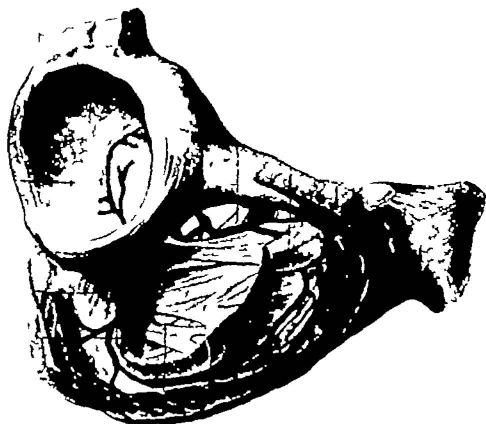


FIG. 6. Distribution of the obturator artery (After Waldeyer) The three main branches (acetabular internus, and externus) are clearly visualized. The termination of the branch to the internal surface of the tuberosity cannot be seen. (Reproduced from Spalteholz, W *Handatlas der Anatomie des Menschen.* Leipzig S Hirzel, 1921)

surface of the tuberosity and (3) an external branch that follows a similar path along the outer surface of the obturator membrane. 'The ischium is supplied with bone arteries through both of these branches but especially through the ramus internus" (Fig 6)

The venous drainage of the ischium into the *inferior* vena cava is effected through the obturator vein which, in general, follows the course of the obturator artery There are, in addition, important connections between the caval drainage of the ischium and the vertebral venous system, described in detail by Breschet,[4] and to which attention has been directed by the

studies of Batson[2,3] and others.[1,5] These may be of importance in accounting for infectious and neoplastic embolization specifically to the ischium.

No information is available about the lymphatic drainage of the ischium.

The periosteum covering the bone, and possibly the ischium itself derive nerve supply through the obturator nerve.

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CHAPTER 2

Physical and Roentgenographic Examination of the Ischium

PHYSICAL EXAMINATION

THE EXTERNAL OR femoral aspect of the ischium is covered by the heavy mass of the pelvifemoral musculature and is not easily accessible to physical examination. In extension or the erect position of the body the tuberosity of the ischium is hidden beneath the lowermost fibers of the gluteus maximus muscle, but can be located by inserting the fingers under these fibers in the gluteal fold. In flexion, whether in the seated or the lithotomy positions, the tuberosity glides from under its gluteal muscle covering and becomes practically subcutaneous In all positions, the ischial ramus is subcutaneous and can be readily examined in the perineum.

The whole of the internal or pelvic aspect of the ischium, from the tip of its spine to its junction with the pubis, is readily palpable either by rectal or vaginal examination. By these routes the sacrospinous ligament, the distal end of the sacrotuberous ligament, the tuberosity and the body of the ischium, the lower part of the obturator membrane covered by the obturator internus muscle, and the entire length of the ischial ramus are available for digital exploration. The existence of edema, point tenderness, irregularities in configuration, as well as localized accumulations of fluid that might other wise be overlooked can be easily discovered. Such examination is of the utmost importance and should never be neglected in routine examination of

the ischium, or indeed, of any condition in which there is limitation of motion of the hip

Topographically important structures about the ischium may be accurately located by their relation to a subgluteal triangle the apices of which are the posterior superior iliac spine, the tip of the great trochanter and the ischial tuberosity (Fig 7) On the line drawn from the posterior superior iliac spine to the great trochanter the gluteal artery and the suprapyriform portion of the great sacrosciatic foremen lie at the junction of the inner and middle thirds, while the base of the ischial spine and the head of the femur lie at the junction of the middle with the outer thirds. On the line drawn from the trochanter to the ischial tuberosity (the posterior half of Nelaton s line) the femoral neck lies at the junction of the outer and middle thirds, while the sciatic nerve lies at the junction of the middle and inner thirds. On the line joining the posterior iliac spine with the tuberosity the ischial spine, the infrapyriform portion of the great sacrosciatic foramen, and the structures entering the lesser sacrosciatic foramen lie approximately at the level of its mid point.

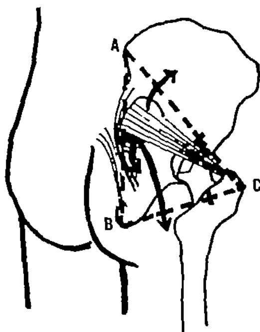


FIG. 7 The subgluteal triangle The superior gluteal artery and the suprapyriform portion of the great sacrosciatic foramen are located at the junction of the inner and middle thirds of the line *AC* The inferior gluteal artery the infrapyriform portion of the great sacrosciatic foramen and the base of the ischial spine are located at the mid-point of the line *AB* The sciatic nerve lies at the junction of the inner and middle thirds of the line *BC*

All these references are relative and depend upon the assumption that the points that determine the lines are in their relatively normal positions. Objective evaluation of the topographical relationship of Nelaton s line or Bryant s triangle is meaningless unless it can be established that the lines of reference are identical on both sides of the body It is common practice to describe the great trochanter of the femur as being above Nelaton s line" or "closer to the base of Bryant s triangle" on one side or the other The clinical implication is that something has occurred between the great trochanter and the pelvis to warrant the suspicion, among others, of a fracture of the femoral neck, a dislocation of the femoral head, or a coxa vara deformity This is not necessarily the case since it is evident that the change in relationship may just as well be due to a depression of the line of

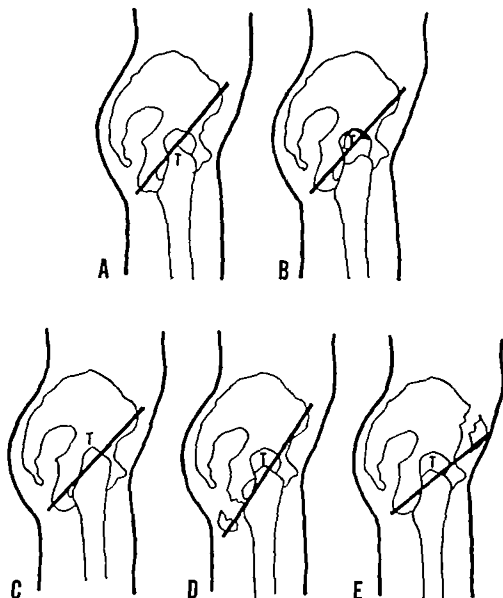


FIG. 8 Use of Nelaton's line. Without measurement of the distances between the anterior superior spine of the ilium, the ischial tuberosity the tip of the great trochanter and the internal malleolus, elevation of the great trochanter above Nelaton's line has no significance. *A* the normal relationship *B* the tip of the trochanter is above Nelaton's line because of fracture of the trochanter with upward displacement of the small fragment. The distance from the tip of the trochanter to the malleolus is increased. *C* the trochanter is above Nelaton's line because of coxa vara, fracture of the femoral neck, or dislocation of the head. The distance from the ischial tuberosity and the anterior superior iliac spine is decreased as compared with the normal side. *D* the trochanter is above Nelaton's line because of fracture of the ischial tuberosity The distance from the ischial tuberosity to the malleolus is decreased but the other measurements are identical with those on the unaffected side *E* the trochanter is above Nelaton's line because of fracture of the anterior superior iliac spine The distance from this point to the malleolus is decreased while the other measurements are unchanged as compared with the normal side.

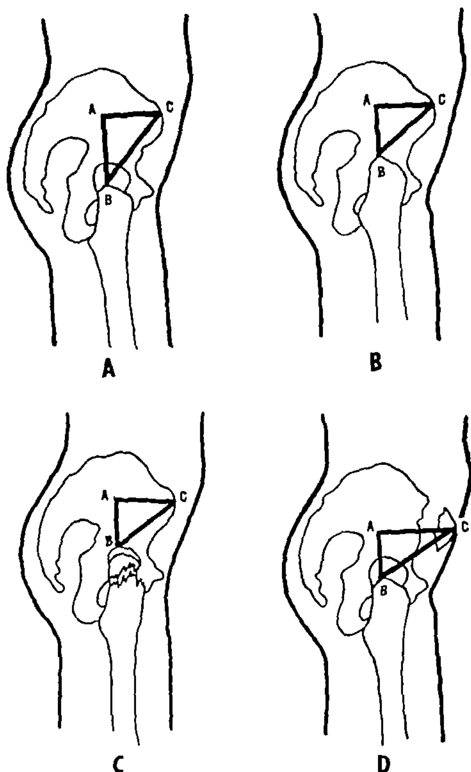


FIG. 9 Use of Bryant's triangle. *A* the normal relationship *B* the base of Bryant's triangle is shortened as a result of coxa vara, fracture of the femoral neck, or dislocation of the femoral head *C* the base of the triangle is shortened as a consequence of fracture of the great trochanter with upward displacement of the fragment. *D* the base of the triangle is shortened as a result of downward displacement of the fractured anterior superior iliac spine.

reference as to an elevation of the trochanter Such situations may arise, for example from antecedent avulsion of the ischial tuberosity the anterior superior spine of the ilium or in fact, from a fracture of the trochanter itself without any change in the position of the femoral head or neck or any damage to the acetabular margin.

The significance of Nelaton's line lies in the accidentally discovered fact that the base of the great trochanter in the flexed position, or the tip of the trochanter in the extended position lies on the line that joins the anterior superior iliac spine with the ischial tuberosity The collinearity of any three points in space is an extremely fortuitous circumstance and a change in any one of the points necessarily involves a change in the geometrical relationship of the other two This geometrical relationship can acquire meaning only if it is supplemented (Fig 8) by arithmetical determinations of the actual distances of the three points from a fixed point of reference such as the internal malleolus.[2]

Thus, it is evident that elevation of the great trochanter above Nelaton's line, in the sense of a fracture of the femoral neck or a dislocation of the head, acquires diagnostic significance only if the distance from the tip of the trochanter to the malleolus is unchanged while the distances from the anterior superior iliac spine and the ischial tuberosity are less on the affected than on the opposite side. Increase in the distance from the tip of the trochanter to the malleolus, the other two distances being unchanged as compared with the opposite side, would be suggestive of a fracture of the great trochanter Diminution of the distance from the ischial tuberosity or from the anterior superior iliac spine without any change in the trochanter malleolus distance, as compared with the opposite side would suggest an avulsion fracture of the apophysis of the tuberosity of the ischium or of the anterior superior iliac spine respectively rather than any pathology in the region of the femoral head or neck Precisely similar criticism must be made of the routine use of Bryant's triangle (Fig 9)

ROENTGENOGRAPHIC EXAMINATION

In the last analysis, diagnosis in any condition involving the ischium will depend upon roentgenographic visualization of the part involved All the surfaces and borders of the ischium can be readily submitted to x ray examination by means of four exposures anteroposterior anterior oblique, posterior oblique, and lateral. Examination of the ischium should always begin with a simple anteroposterior view of the entire pelvis so that the topographical relationships as well as the comparative appearance of both ischia can be made. Though it would hardly seem necessary to insist on matters of technique, disregard of standard practice, especially with respect

to the symmetrical placing of the patient, has led to numerous erroneous conclusions.

For the normal anteroposterior view the patient should be in the supine position with the legs parallel and both iliac spines at the same level, on a line perpendicular to the longitudinal axis of the body (Fig 10) If the pelvis cannot be brought into the standard position because of contracture of the hips or flexion of the lumbar spine no effort should be made to extend the legs, and the x ray tube should be so tilted as to give a relatively normal projection of the pelvis. Thus, if as a result of ankylosing spondylitis, the pelvis is tilted upward fifteen degrees, the x ray tube should be similarly tilted fifteen degrees so that the central beam is directed from in front and above. It is extremely important that absolutely symmetrical exposures be made and especial care must be taken to avoid rotatory displacement of the pelvis.



Fig. 10 Normal anteroposterior view of the pelvis. This standard view permits rapid orientation of both ischia provided the exposure has been symmetrically made.

Generally speaking the normal anteroposterior view of the pelvis will present essentially the same appearance on both sides. Unilateral prominence of the ischial spine may occasionally be noted, but it may be considered as insignificant if there is indisputable evidence of asymmetrical exposure as evidenced by displacement of the mid sacral axis toward the side of the apparent lesion, relative diminution of the size of the obturator foramina, or relative increase in the width of the ilium as compared with the opposite side (Fig 11)

Lamy and Vincent,[1] who became interested in this subject because of false diagnoses of acetabular fractures in infants, showed that rotation of the pelvis resulted in prominence of the spine of the ischium on the side toward which the pelvis was rotated Similarly bilateral prominence of the



FIG. 11 False ischium varum. The ischial spine appears abnormally prominent. Asymmetrical exposure is betrayed by the difference in the width of the iliac alae, the asymmetry in contour of the pelvic inlet, and the difference in the size of the obturator foramina.



FIG. 12 Bilateral false ischium varum. The pelvic inlet is abnormally large and round, the ischial spines are above their normal level, and the obturator foramina can barely be visualized because of the downward tilting of the pelvis.

ischial spines resulted from excessive forward tilting of the pelvis. This projective illusion could be recognized by the fact that the ischial spines were projected at a higher level than normal, that the contour of the pelvic inlet was abnormally large, that the sacrum was abnormally horizontal, and that the obturator foramina were abnormally small (Fig 12)

The anteroposterior appearance of the pelvis will vary with the age of the patient up to the time when complete maturity has been reached. The first and most striking difference to be noted in the roentgenogram of the infantile pelvis, up to about the age of eight, is the discontinuity that exists



FIG. 13 Pelvic roentgenogram in a child aged six months. There is discontinuity at the ischiopubic junction. The three components of the acetabulum are clearly visualized.



FIG. 14 Pelvic roentgenogram in a child aged eight years. The ischiopubic epiphysis has closed with slight bulbous thickening. The acetabular cavity appears to be formed by a small superior iliac portion and a large inferior ischiopubic portion. Shenton's pubofemoral line and Lamy's iliofemoral line are smooth and continuous.

between the pubic and ischial rami (Fig 13) This junction is cartilaginous and the defect becomes gradually smaller as the normal age of ossification of this area is approached. Normal closure of this epiphyseal line occurs at about the age of eight. Closure may occur earlier or later and with or without nodule formation. Although the bulbous form of closure has been con-

sidered pathognomonic of ischiopubic osteochondritis, it must be emphasized that nodular closure of the ischiopubic epiphysis may occur normally In the absence of any specific symptomatology nodule formation in this region cannot be considered as anything more than a normal variation (Fig 14)

The most striking appearance is that of the apparent discontinuity of the bones that enter into the formation of the acetabulum. The os innominatum is developed from three separate centers of ossification that appear during



FIG. 15 Anterior oblique view of the pelvis. The thigh on the affected side is flexed and rotated outward. The central beam is directed anteroposteriorly affording a good view of the lateral and medial walls of the ischium.

the second to fourth month of intrauterine life. At or shortly after birth, the y-shaped cartilage that separates these three centers divides the acetabulum into three equal parts. Later the acetabulum appears, roentgenographically to be divided into two unequal parts a smaller superior part, forming the roof of the acetabulum and derived entirely from the ilium, and a larger inferior part, which forms the medial wall and cavity of the acetabulum and is derived from the ischium and pubis. (On an anteroposterior view the descending branch of the tripartite cartilage separating the pubis and the ischium is not readily visualized.) The other two branches

of the tripartite cartilage the iliopubic and the ilioischial cartilages do not lie in the same anteroposterior plane but are largely superimposed one upon the other in the anteroposterior roentgenogram of the pelvis. As a consequence, a single relatively clear space appears between the smaller superior iliac part of the acetabulum and the larger inferior ischiopubic portion of the acetabulum



FIG. 16. Posterior oblique view of the pelvis. The patient is turned about twenty degrees toward the affected side with the unaffected thigh lying above and in front of the involved side The central beam is directly above affording a view of the entire outline of the obturator foramen.

On anteroposterior views of the pelvis, regardless of age, it will be found that a relatively smooth curve can be drawn along the lower border of the femoral neck into the outline of the ascending ramus of the pubis This is known as *Shenton's pubofemoral line* and a break in the normal smooth continuity of this line has been characteristically found in dislocations of the hip An iliofemoral line drawn along the outer edge of the iliac wing and then along the upper border of the femoral neck (*Lanty's line*) is of less diagnostic significance While the smooth continuity of this line may be broken in cases of dislocation of the femoral head or fracture of the femoral

neck, the appearance of discontinuity may also arise from simple rotation of the pelvis.

Though the normal anteroposterior view of the pelvis usually suffices for general survey of the whole of the ischium, it may occasionally be desirable to obtain special views for the purpose of more carefully examining specific regions. For this reason anterior oblique, posterior oblique, and lateral views may be helpful.

The anterior oblique view for examination of the lateral and medial



Fig. 17 Lateral view of the pelvis. The patient may be placed in the supine position with both thighs completely flexed on the abdomen The central beam is overhead and affords a view of the posterior and inferior borders of the ischial tuberosity, the notch for the passage of the obturator externus tendon and the lower margin of the acetabular cavity

walls of the ischium, is obtained by flexion of the thigh on the affected side and rotating the thigh outward until it and the pelvic wall lie in the plane of the x ray table directly beneath the overhead x ray tube. This gives an oblique view of the pelvis, but the central beam of the x ray is parallel to the oblique position of the ramus of the ischium (Fig 15)

The posterior oblique view for examination of the margins of the obturator foramen and the posterior and inferior borders of the ischium, is obtained with the patient lying on the affected side. The body is rotated about twenty degrees so that the upper or uninvolved limb lies anterior to the part being examined. This serves to bring the obturator foramen into the plane of the x ray film directly under the central beam of the x ray tube (Fig 16)

The lateral view for visualization of the posterior and inferior borders of the ischium, the inferior surface of the acetabulum, and the groove immediately below which transmits the obturator externus muscle, is obtained with the patient lying in the lateral position. The thighs are spread sufficiently to permit passage of the x ray beam that is directed from in front and below to above and behind against a vertically placed film cassette. A similar exposure may be obtained with the patient in the supine position with the thighs flexed to a right angle and the pelvis tilted slightly upward (Fig 17)

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CHAPTER 3

Ischium Varum

ˀHIUM VARUM" is a designation that has only recently acquired stature in ˀopedic terminology. Despite this, it has already been employed to de be two different conditions, one of which is characterized by a real, the er by an apparent decrease in the distance between the ischial spines. m the point of view of the orthopedic surgeon, the interspinous distance, n when there is a real decrease, has little importance, except perhaps as icating a change in the obliquity of the ischium and therefrom a change he angle of inclination of the lateral wall of the pelvis. It is, of course, major importance to the obstetrician for whom excessive narrowing of transverse diameter of the pelvic outlet may constitute a serious cause of tocia.

TRUE ISCHIUM VARUM

trictly defined "ischium varum" indicates nothing more than an axial nge in the orientation of the ischial wall to the mid line. It should there-, be applied only to those instances in which, as in the funnel-shaped is, there is an actual inward deviation from the normal in the angular tionship of the plane of the ischium to the sagittal plane of the body ual inward angulation of the wall of the true pelvis may result from oacetabular fractures (Fig 18) or from more complicated pelvic in-es such as occur in Malgaigne's fracture. In one such case reported by et, narrowing of the pelvic outlet was so marked as to necessitate forceps very during the course of which the ischium was broken.

hese inward angulations necessarily determine a medial approximation he ischial spines and a consequent reduction in the interischial or inter ous diameter The anteroposterior roentgenogram of the pelvis in such ents will show an abnormal unilateral or bilateral prominence of the

ischial spine that is consonant with the obliquity of the pelvic wall and an actual decrease in the interspinous diameter It is evident that true ischium varum must manifest not only a real decrease in the interspinous diameter such as may be suspected from the roentgenographic evidence of prominent ischial spines but also specifically actual increase in the obliquity of the pelvic wall.



FIG. 18. True ischium varum in ischioacetabular fracture. The whole wall of the pelvis has been displaced inward with narrowing of the pelvic cavity

FALSE ISCHIUM VARUM

True increase in the inclination of the pelvic wall must be carefully distinguished from false or apparent obliquity Decrease in the interspinous diameter is not necessarily associated with increased obliquity of the pelvic wall and may be seen in the Robert s, the Naegle, the transversely contracted, the Otto s, the osteomalacic, the android, the coxalgic, and other types of dystocic pelves. In all of these the position of the ischium is undoubtedly abnormal, but without any evidence of increased obliquity specifically varus, with respect to the mid line of the body The roentgenograms of such pelves, naturally disclose abnormal medial approximation of the ischial spines resulting from their actual medial displacement. It is possibly as a consequence of this similarity with the funnel shaped pelvis that such roentgenographic evidence has been accepted as the hallmark of varus of the ischium. This is the more unfortunate in that the weight of authority has cloaked such evidence with a verisimilitude that more critical analysis does not warrant.

Influenced by the work of Le Demanay[3] on the effect of interuterine pressure on the fetal hip and the work of Calot[3] on the significance of the change from the half-orange shaped normal acetabulum to the half lemon-shaped dysplastic acetabulum, Murk Jansen[3] evolved a complicated theory that was intended to explain the pathogenetic equivalence of a whole series of hip anomalies.

In these affections, there is not always a flattening of the socket through a thickening of the floor In a relatively large number of cases, the floor of the

ket is of normal thickness, but the os ischii has swung on a turning point ated about the middle of the acetabulum, so that its lower part points inward. e foramen obturatorium has thus become smaller on that side than on the rmal side, so that, at first sight, one is inclined to ascribe the difference to mmetrical exposure. However when ischium varum is present, this difference found when the parts are exposed with perfect symmetry We have sons for believing that the hip socket may not only become flat and wide, : also twisted. In short, congenital hip dislocation is often found com- ed with a flat hip socket (through a thick socket floor or with a wide socket ough ischium varum or a V-shaped pear figure) just as it is often combined h coxa vara, coxa fracta, coxa valga, coxa plana, slipping epiphysis, or malum cae.

While the somewhat indiscriminate grouping of conditions, as different tologically as Perthes disease, slipping of the upper femoral epiphysis, and ngenital dislocation of the hip, cannot be accepted at the present time, re are other equally valid grounds for a healthy skepticism with respect Jansen s explanation and specifically his validation of the concept of hium varum. In the first place, there appears to be serious confusion in rrelating the wide maternal pelvis, which is essential to delivery of the ge brained fetus, with the wide fetal pelvis, which is the alleged cause of : various hip anomalies previously noted The former is concerned with : interior of the maternal pelvis, the latter with the exterior of the fetal lvis. Even if such a relationship could be established as a teleological neces- y the relative infrequence of any one or all of the hip anomalies taken gether does not seem to have been substantiated on a statistical basis. In a ent study of two hundred adult pelves (one hundred male and one hun- ed female) R. A Milch noted that there was no correlation between the erior of the true pelvis and the external characteristics of the lateral pelvic ill or the interacetabular distance.

Still more important is the fact that practically all the evidence adduced Murk Jansen is of a roentgenographic nature. Such data are notoriously itrustworthy with respect to line or angle measurements. Neither of these terminations is invariably projective unless special attention is given to sure parallelism of the roentgen plate with the part to be x rayed and per ndicularity of both to the central beam of the x ray Aware of these re ictions, Boerema[1] undertook to review twenty five cases of Perthes dis- se in whom Jansen had postulated the existence of a flat acetabulum and chium varum as manifested by intrapelvic protrusion of the ischial spines. n the anteroposterior views of all these cases, Boerema did, in fact, find ch protrusions. In nine cases, however a number of views other than the iteroposterior were made and these, strangely enough, did not show the aracteristic ischium varum. Boerema quickly noted that the so-called iteroposterior views were not in fact entirely symmetrical and expressed

the opinion that Jansen's results were obtained on asymmetrically exposed pelves.

In confirmation of this opinion, Boerema showed that unilateral prominence of either ischial spine could easily be produced by rotation of the pelvis toward the same side. This was independent of any hip involvement. Its appearance in clinical cases was due to the coexistence of hip contractures which enforced ipsilateral rotation of the pelvis (Fig 19) By appropriate positioning of the patient, so called ischium varum could be simulated on the completely normal side. This type of asymmetry can be quickly recognized by comparison of the relative size of the obturator foramina, or the iliac alae and the displacement of the axis of the sacrum from the mid line of the symphysis pubis toward the side of the apparent ischium varum He showed further that apparent bilateral intrapelvic protrusions of the ischial spine could be routinely produced by experimental tilting of the pelvis into a position of lordosis such as would constantly be present in flexion contractures of the hips. In extreme positions, this type of asymmetry would probably be readily recognizable from the elevated position of the sacrum, the configuration of the pelvic rim, the foreshortening of the obturator foramina and the high displacement of the ischial spines. In lesser degrees of flexion of the pelvis, these stigmata of asymmetry might be easily overlooked or be impossible of verification.



FIG. 19 False ischium varum. The prominence of the ischial spine on the right side arises from the fact that the x-ray was made in an asymmetrical position with the pelvis rotated and flexed, owing to fusion of the right hip joint

These observations are well illustrated in the following case

M., aged seven, had been under treatment for a year for Perthes disease of the right hip. Roentgenograms made in the symmetrical position disclosed the characteristic appearance of the condition without any protrusion of the ischial spines (Fig 20) With the pelvis rotated toward the side of the lesion, the ischial spine immediately became prominent. When the child was placed in the supine position with a pillow under the lumbar spine to simulate the tilting of the pelvis



FIG. 20. False ischium varum in Perthes disease. The ischial spine is prominent owing to rotation of the pelvis as is indicated by the asymmetrical appearance of the obturator foramina.



FIG. 21 The same as Figure 20 The prominence of the ischial spine has been reduced by rotating the patient slightly to the left. Complete symmetry of exposure has not been attained as is evidenced by the appearance of the obturator foramina.

that could result from flexion contractures of the hip, both ischial spines were visualized. The greater prominence of the spine on the affected side was clearly due to rotation as was indicated by the disparity in size of the obturator foramina (Fig 21)

PSEUDOFRACTURE OF THE ISCHIUM

Asymmetrical exposure of the pelvis and the failure to recognize the illusory nature of the so-called ischium varum to which it may give rise have

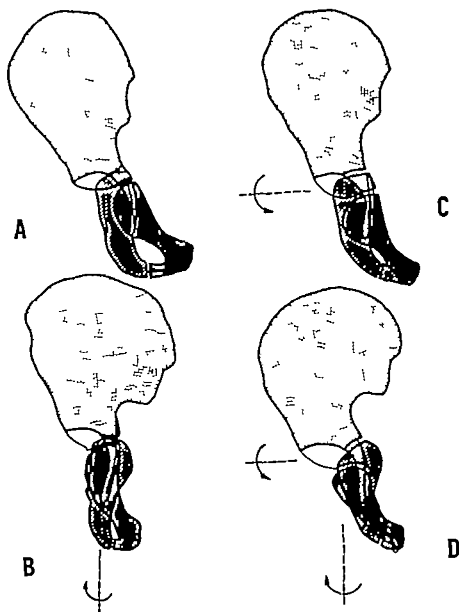


FIG. 22 Positions of the ischium in various positions of the pelvis. *A*, the normal appearance In *B* the pelvis has been rotated 30 to the right, the ischial spine is prominent. In *C* the pelvis has been tilted forward the spine is higher and is slightly prominent the ischium is foreshortened. In *D* rotation as in *B* has been superimposed on the lordosis of *C* with resulting prominence of the ischial spine. (Reproduced from Lamy L., and Vincent, J La fausse fracture du cotyle chez l enfant *Bull. et mem Soc Chirurgiens Paris 29* 79 1937)

led to other clinical misconceptions. Sporadically case reports have appeared in the literature that have been designated as unilateral protrusion of the acetabulum (Otto s pelvis) fracture or dislocation of the ischium, or epiphyseal separation of the ischium. These latter conditions have usually been described in young children in whom there have been physical signs of a coxitis with flexion and adduction deformities of the hip on the affected side. The child has usually walked with a limp and passive motion of the hip

has usually been limited so that clinical evaluation of the condition has been difficult. The diagnosis has almost invariably been made on the basis of a roentgenogram disclosing a unilateral abnormality on the side of the hip signs.

Considering the intrinsic strength of the pelvic articulations, the possibility of such acute occurrences in the absence of a massive pelvic injury seems highly unlikely. The possibility of reduction of such displacements by gentle manipulation such as has been described by Schoolfield[7] seems not only unlikely but highly improbable.

Confronted on several occasions with situations in which the diagnosis of fracture or dislocation of the acetabulum had been made but where, in their opinion, no such displacement existed Lamy and Vincent[4] came to the conclusion that the roentgenographic diagnosis represented "an error of interpretation." They called attention to the fact that, in all the cases seen or reported, the roentgenograms had been taken with the pelvis in lordosis and rotated toward the side of the affected hip (Fig 22) In two cases in which they present roentgenographic data they were able to "cure" the lesion by simply correcting the pelvic malposition. Furthermore, they were able to produce an identical "lesion" on the opposite side by replacing the pelvis in lordosis but rotated toward the opposite, unaffected side.

Since the roentgenogram presents only an optional projection, an illusion, it is clear that the "lesion" may be no "lesion" and the "cure" no "cure." Before the diagnosis of a pelvic displacement can be made there must be absolute assurance that the pelvis is placed in a completely symmetrical position with respect both to the central beam of the x ray and the x ray film. Where the assumption of such standard position is impossible, the roentgenologist as well as the clinician must be consciously aware of the varied appearances to which change in the position of the pelvis may lead. As in all axial displacements, a small x ray film disclosing only one side or a small portion of the pelvis is completely useless. A view of the entire pelvis is fundamental to accurate diagnosis. Where doubt arises, x rays in the standard position as well as the oblique positions are essential to the avoidance of error in describing as actual pathology appearances that result from nothing more than axial shifting of the pelvis.

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CHAPTER 4

Intrapelvic Protrusion of the Acetabulum (Otto's Pelvis)

INTRAPELVIC PROTRUSION OF the acetabulum was first described as a pathological entity by Otto in 1824 The additional designation of "Chrobak pelvis" was made entirely gratuitously by Eppinger[a] and was not warranted by any contribution of Chrobak to a better understanding of the condition. Ignoring Otto s specific etiology of "gout," which, with a more liberal connotation, might be extended to designate arthritis of a nonspecific origin, nothing essentially new has been added to Otto s description.

Otto noted

> the acetabulum protrudes so far into the pelvis that it contains not only the head but also the normally long neck of the femur and the upper acetabular margin articulates with the great trochanter The entire inner aspect of the acetabulum is smooth as well as the head of the femur Both are devoid of cartilaginous covering and have the abraded and polished appearance of some gouty joints, only the portion of the head opposite the acetabular defect is roughened and eroded by absorption. The acetabular margin is rough and uneven, slightly thickened, and so constricts the femoral head that the large head cannot be removed from the cavity of the joint. The transverse ligament of the acetabulum is ossified. (Since the roughened large trochanter grates on the roughened acetabular margin and since the femoral neck is somewhat angular and the small trochanter hits the sciatic tuberosity on backward flexion of the femur the femur itself can be rotated only slightly forward and inward but not outward and backward. Thus, the joint is so restricted that the abdomen and thigh form a right angle in the standing position.)[a]

Despite this classic description of its pathologic anatomy the condition was clinically recognized only rarely Up to 1889 Schauta[38] noted only thirteen true cases. With the development of x ray diagnosis and the careful description of its roentgenographic appearance by Kienbock[18] the condition has been recognized more frequently and the symptomatology has been more clearly defined. Even so the condition is not common and up to 1932, Pomeranz[33] roentgenographically recognized only somewhat over forty cases.

The incidence of the affection appears to be definitely greater in females



FIG. 23 Unilateral intrapelvic protrusion. Female aged sixty five years. History of a fall three years earlier with the onset of signs of rheumatoid involvement of the left knee, both hands, cervical spine, and both temperomandibular joints one year later The intertuberosity distance on the affected side is much smaller than on the normal side.

than in males. It occurs predominantly in adults but has also been reported in younger people, the youngest being a girl of ten (Esau[9]) Though it may appear unilaterally (Fig. 23) the condition is more commonly seen with bilateral involvement of the hips. Its onset is gradual with or without pain and a hip limp suggestive of coxitis. This may account for its designation, in the preroentgen era as arthritis

While the presenting symptoms are frequently those of arthritis of the hip joint, the question naturally arises as to whether arthritis is the primary cause of the affection or whether the disordered anatomy may not give rise to secondary arthritis. Some students incline to the opinion that the arthritis is

the cause of the protrusion. Others have reported cases in which Otto's pelvis was a purely accidental finding in entirely asymptomatic individuals. Depending on the severity of the process, patients may be entirely symptom-free until some intercurrent injury directs attention to one hip, at which time the opposite side may be found to present an identical intrapelvic protrusion without any signs of an arthritic involvement.

The patient usually presents himself for the relief either of pain or of limitation of motion. On examination, he may be found to walk with a limp or waddle. In the unilateral cases, there may be a slight relative shortening of the affected limb and the distance between the great trochanter and the mid-line of the body will be less on the affected than on the normal side. Limitation of motion will be of variable degree. Because of the gradual inward protrusion of the acetabulum with gradual inward displacement of the femoral head and neck, abduction and rotation are first limited by contact of the glenoidal margin against the femoral neck. When the protrusion has reached its maximum, about four centimeters, contact of the great trochanter with the acetabular margin leads to limitation of abduction, while contact of the lesser trochanter with the ischial tuberosity will limit backward extension. On rectal palpation, the inward bulging of the inner wall of the pelvis in the region of the acetabulum is readily recognizable.

X-RAY STUDY

The x ray appearance is pathognomonic of the condition (Fig 24) The inner wall of the pelvis bulges abnormally inward and the femoral head projects beyond the arcuate line, which defines the inlet to the true pelvis. The distance between the ischial tuberosity and the lesser trochanter (inter tuberosity distance) is decreased as is the distance between the great trochanter and the glenoidal margin. The femoral neck appears foreshortened and the tear drop is distorted or may be entirely absent.

Köhler[1] was the first to call attention to this phenomenon and Vare[23] concluded that.

> the lateral border of the pelvic tear drop, therefore, is made up of the cortical surface of the middle third of the acetabular fossa, commencing at the lunate surface proximally and extending to the cotyloid notch inferiorly Continuation through the obturator foramen marks the inferior aspect of the roentgenographic structure. The medial aspect of the tear figure is made up of the cortical surface in the true pelvis, where a groove for the obturator vessels and nerves exists, continuing in the same plane as far as the arcuate line immediately posterior to the iliopectineal eminence.

This description is clearly in consonance with Kohler's observation on the distortion of the tear drop and the known displacement or replacement of the medial wall of the acetabulum and the inner wall of the true pelvis.



Fig. 4 Bilateral intrapelvic protrusion of the acetabulum. Apart from slight limitation of rotation, the patient had no symptoms. The femoral heads project beyond the arcuate line and no teardrop figure is seen on either side. There are no signs of arthritis.



Fig. 5 Bilateral intrapelvic protrusion. On the right side there was greater penetration, signs of osteoarthritis, and clinically marked pain. On the left side, there was no pain but moderate limitation of extension and rotation.

In some instances, the wall of the acetabular protrusion may be very thin. In others, probably as the result of a reactive osteoplastic process, it may be thick. Its pelvic contour is usually smooth and hemispherical, but, in cases such as arise as a result of acetabular fracture, the wall may be irregular and even somewhat nodular

Intrapelvic protrusions, when of moderate degree, may give rise to few if any symptoms. When marked protrusion occurs, limitation of hip motion may follow but the appearance of pain is usually indicative of the development of arthritic manifestations. In such instances, the roentgenogram will present, in addition to the acetabular deformation, the sclerosis, joint narrowing and osteophyte formation characteristic of *hypertrophic arthritis* (Fig 25)

ETIOLOGY

The most interesting of the discussions concerning this condition have naturally centered about its etiology In most instances, and usually on the basis of relatively few observations, different students have attempted to establish a unique pathogenesis. Though most incline to the opinion that arthritis is the predisposing cause leading to intrapelvic protrusion, other etiologies have been described. It has been reported as occurring in association with tabes dorsalis, Paget s disease, and metastatic malignancy Valentine and Müller[24] and Zwicker[30] have described it as a sequel of tuberculous coxitis and Henschen[10] recorded it in seven cases of ecchinococcus infestation. Esau[4] observed the appearance of Otto s pelvis after osteomyelitis and Hertzler[11] noted it in a woman of forty four who at the age of six years had suffered from an infection of the hip joint. Schlagenlaufer[21] reported it after a Neisserian infection of the hip joint and Sloane and Sloane[23] described the case of a woman of eighteen from whose hip joint the gonococcus was recovered and in whom serial x rays taken over the course of a year clearly documented the development of a unilateral intrapelvic protrusion

Schaap[19] in commenting on a case reported by Waller came to an entirely different conclusion. His case was that of a woman of twenty-one, who five years earlier had fallen off a bicycle landing on her left hip. X rays taken at the time disclosed pre-existing bilateral intrapelvic protrusions. Two years later the condition of the right hip remained unchanged while the left hip showed evidence of progressive disability On the basis of the well-recognized predisposition of the female pelvis toward dysplasia of the hip, Schaap expressed the opinion that the primary cause of Otto s pelvis was a congenitally deep acetabulum with decrease in the angle of the femoral neck owing to some ovarian dysfunction.

The progressive appearance of arthritic symptoms on the injured side, however would appear to be better explained on the basis of a trauma superimposed on an underlying intrapelvic protrusion. Froelich[8] reported a case in which, following a fall on the right hip, symptoms developed on that side only though x rays demonstrated the existence of bilateral intrapelvic protrusions. Similarly Saupé[18] reported a case of bilateral Otto s pelvis in which unilateral symptoms appeared only on the side of in-

jury and two other cases of unilateral intrapelvic protrusion that developed only on the side previously injured. Lewin[14] described the case of a man sixty-four years old, who developed osteoarthritis of the left hip following a fall on both feet eighteen years previously. X-ray examination revealed the typical appearance of an Otto's pelvis on the left side, while the right hip was completely normal.

While this seems to establish the importance of trauma with respect to the onset of symptoms because of a secondary arthritis in a previously affected



FIG. 26. Central fracture of the acetabulum. The acetabular floor has been displaced inward and the head of the femur protrudes beyond the normal position of the pelvic wall.

hip joint, it also raises the question as to the significance of trauma as a primary cause of the condition. Benda[1] reported the case of a nurse forty-two years old, who had limped for a period of twenty years following a fall. The x-ray disclosed a unilateral intrapelvic protrusion at the femoral head, which was considered as owing to a traumatic arthritis. Though Benda categorically rejected fracture of the acetabulum as a cause of intrapelvic protrusion, this possibility cannot be dismissed too lightly.

There is no doubt that central fractures of the acetabulum can result in unilateral protrusion (Fig. 26). In a case described by Delannoy[3] a man, forty-seven years old, fell a distance of two and a half meters, landing on his right side. Though he presented signs of ecchymosis, swelling and pain over

the great trochanter rectal examination was completely negative and a diagnosis of contusion of the hip was made Re-examination performed several days later however disclosed a definite protrusion on rectal examination and an acetabular fracture similar to that seen in Fig 27 on x ray examination.

In another case reported by Lobel,[18] a female age fifty-one complained of pain in both hips following a fall thirty three years earlier No evidence of injury was found at that time but, subsequently the patient presented evidence of bilateral intrapelvic protrusions. While the pre-existence of ace



FIG. 27 Central fracture of the acetabulum. Following healing of the fracture, the smooth inner wall of the pelvis shows no evidence of the antecedent fracture.

tabular fractures cannot be objectively documented, it is noteworthy that the injury described in this case is precisely the same as that which has been described as one of the causes of acetabular fractures.

In this context, it is interesting to note a case of bilateral acetabular fracture following shock therapy reported by Haines.[9] Roentgenograms taken immediately after complaints of pain in the hip revealed that bilateral acetabular fractures had occurred in a young boy of seventeen afflicted with unrecognized bilateral intrapelvic protrusions. When the history was later reviewed it was discovered that, at the age of seven, the young man had gone through an attack of inflammatory rheumatism without any signs of hip involvement. It was only after a subsequent convulsive seizure of undetermined etiology that the patient began to limp X ray at that time was

reported to have been negative and a diagnosis of osteochondritis was made. In view of the later muscular fractures of the acetabula following the shock therapy it is probably not too far fetched to assume that the young man may have suffered similar but minimal central fractures, which led to the development of the bilateral Otto's pelvis after the original convulsive seizure.

It will be recalled that Thevenot,[37] Fanton,[7] Dupuytren[4] and others have called attention to the fact that central fractures of the acetabulum were more frequent than was commonly supposed that simple fractures could be easily overlooked or misdiagnosed, and that central displacement could occur if weight bearing was permitted before complete bony union had taken place. In such event, it could be expected that the central portion



FIG. 28. Bilateral intrapelvic protrusion. Fusion was unsuccessfully attempted on the left side, with persistence of pain and limitation of motion.

of the acetabulum would show evidence of nonunion. Precisely this condition, a central defect, was noted both in the original observation by Otto and in the observations by Eppinger. It may well be that Eppinger's rejected concept of delayed ossification attributable to a disturbance in acetabular development resulting from chondrodystrophic or chondroepiphyseal changes may with greater merit be attributed to nonunion resulting from unrecognized central fractures occurring during adolescence.

Considering all the evidence, it appears that intrapelvic protrusion of the femoral head is a clinical condition with pathognomonic x-ray appearance that may arise from a number of different causes. In general, these may be grouped into those that arise from (1) conditions leading to weakening of the acetabular wall, such as infections, nonspecific inflammations, intrinsic disease of bone, or tumor formation and (2) conditions in which the normal strength of the wall is exceeded by trauma or muscular contractions.

Though intrapelvic protrusions may act as a cause for dystocia as in the cases reported by Benda,[3] Henschen,[10] and Chiari[2] it is only in the severe cases where marked limitation of motion or insufferable pain from the

associated arthritis supervene that treatment is necessary As in the treatment of arthritis of the hip or of the late results from central fracture of the acetabulum, arthrodesis is completely out of the question in bilateral cases. In unilateral cases, fusion may be considered if the patient is willing to sacrifice the possibility of motion for the relief of pain, but fusion is not always successful even in unilateral cases (Fig 78) From a consideration of the results obtained by any of the various prosthetic operations in the treatment of the coxarthritides, the outlook is not hopeful. Where operation is unavoidable, the resection-angulation operation offers the best hope for relief (q v)

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CHAPTER 5

Ischiopubic Osteochondritis

IN 1924 VAN NECK[16] reported the histories of two patients who presented a clinical picture to which he gave the name "osteochondritis of the pubis," but which was later definitely designated as "ischiopubic osteochondritis" by Voltancoli.[17] The first patient, a girl of eight, the only child of tuberculous parents, complained of sudden onset of pain in the right inguinal region. There was some limitation of motion in the hip but no tenderness on pressure over the hip. The right pubic ramus was tender and the right labium was swollen, suggesting the presence of an abscess of Bartholin's gland. Rectal examination disclosed a globular swelling in the right pelvic wall which on later x-ray examination was found to be in the region of the ischiopubic junction. The temperature was elevated but tuberculin tests were negative.

Because of the possibility of a Bartholinian infection, the labium was incised. No pus was obtained but the pubic ramus was found to be uncovered of periosteum and the bone was friable. A specimen of the bone was removed and submitted for pathological examination. By one laboratory the tissue was reported as being a small cell sarcoma, by another as an osteochondritis.

The second case was that of a child aged eleven who had been complaining of limp and pain in the right groin for a period of ten months. There was some limitation of hip motion and a tender swelling in the region of the right pubic ramus. X-ray examination disclosed the typical swelling of the right ischiopubic junction with a normal appearance on the left side. The mass at the ischiopubic ramus was exposed. The periosteum was found elevated over a cherry-sized tumor of bony hard consistency. Section of the tumor "revealed cartilage irregularly seeded with deep red osseous granulation and bony islands. No pus, granulation tissue, or sequestra were found. The mass was considered to be an osteochondritis in the zone of endochon-

dral ossification and the cartilage represents inflammatory lesions without any specific character"[17]

Since Van Neck's earlier description, a number of larger reports by Voltancoli,[17] Asplund,[1] Sanchis-Olmos,[18] Heeren,[8] Haberler,[7] Zeitlin[20] Davidson,[5] Durham,[6] Wülfing[19] as well as a number of shorter case histories by Inclan,[10] Manfredi,[13] Meissner[13] and others[2,9,11,14,15] have appeared in the literature Delitalla is credited by Chianello[4] with having discussed the condition before the Regional Congress of Orthopedics and Radiology at Vienna in 1927 It seems, however that attention was directed to the condition not as a specific entity but rather as illustrating the retardation of closure in the ischiopubic epiphysis in a case of coxa plana.



FIG. 29 Epiphyseal dysplasia. Boy of thirteen years with signs of multiple epiphyseal involvement. In addition to asymptomatic delayed closure of the ischiopubic epiphyses, there is disturbance in ossification of the capital femoral epiphysis.

From a reading of these various contributions, the impression is obtained that a number of variants, if not indeed several different conditions, have been grouped under the heading of ischiopubic osteochondritis. As a consequence the onset of symptoms has been attributed to a varied etiology infection, with tuberculosis specifically excluded, trauma, stress, and epiphyseal dysplasia (Fig 29)

The possibility of stress as an etiological factor cannot be too lightly dismissed even in the more typical cases occurring at an earlier age. All students of the condition have called attention to the fact that the affection manifests itself at a time of great osteogenic activity and at a time of great activity on the part of the child. The symptoms are clearly exacerbated by excessive activity and are mitigated and even cured by rest Moreover the location of the condition at the epiphyseal junction, where maximal muscle strain takes place, where stress fractures occur in older patients, and where gracilis exostoses have been noted, clearly indicates a relation to stress.

Whether the appearance of symptoms must be predicated on a quantit difference in stress or whether an additional factor such as a low grade fection must be assumed is not at present evident.

Despite the lack of unanimity as to etiology the clinical pictu fairly well defined The average age of onset is about seven years an months The youngest child in whom the condition has been diagnosed five years old Since the epiphysis usually closes at about the age of e but may remain open until twelve to fourteen years of age the port of Chiariello[1] in a sixteen year-old patient is most unusual suspicion may, indeed be entertained that this case belongs rather to group of stress fractures than to the true osteochondritides.

The onset may be insidious with gradually increasing pain, limp, low grade fever It may however occur abruptly with severe pain, fever, and prostration suggesting a severe infection. The pain is localize the groin or the hip area and may even radiate to the knee, as in a charac istic hip joint involvement This may of course be explained by the that the obturator nerve, along which the pain radiates, supplies not the hip but also the ischium and the ischiopubic junction. The limp, w present is a typical hip limp While all motions of the hip may be r dicted in the severe case the hip is usually held in flexion and abduction limited motion is possible

Pressure over the greater trochanter of the thigh usually elicits no p but there is invariably pain and tenderness over the ischiopubic junc Swelling over the ischiopubic junction along the inner aspect of the th and even occasionally in the region of the labium, is a frequent observat On rectal examination, tenderness can be elicited over the ischiopubic ju tion and a swelling can usually be detected. Exacerbation of the sympt on activity and their subsidence on rest are highly significant. These s taken in conjunction with a characteristic x ray picture of a cherry hazelnut sized swelling with irregular osteoporosis limited to the region the epiphysis suffices to establish a differential diagnosis between this co tion and a true coxitis.

ROENTGENOGRAMS NECESSARY FOR DIAGNOSIS

Without roentgenographic evidence diagnosis is impossible. The m appearance of nodular swellings in the region of the ischiopubic epiphysi however not in itself sufficient justification for diagnosis of the condit (Fig 30) Caffey[3] has called attention to the fact that the appearance o nodule may be nothing more than a variant in the normal closure of t epiphysis. Heeren[4] studied the pelv tgenograms of ninety five childr in whom the epiphyseal line wa alized. Of these thirty three

tween the ages of two and twelve were found to present the characteristic ovoid swellings with irregularities in ossification at the ischiopubic junction. In the majority of the cases, the finding was purely accidental and bore no relationship to the condition for which the patient was under treatment. On the basis of their x ray appearance, Heeren believed that the entire group should be divided into two subgroups, one of which presented symptoms, the other of which was completely symptom free In the former group consisting of nine patients, the ovoid area of decalcification was surrounded by a somewhat sclerotic zone that was absent in the latter group (Fig 31)



Fig. 30 Normal variant in closure of the ischiopubic epiphysis in a boy of nine years. On the right side the epiphysis has closed with nodule formation. On the left side, closure is still incomplete and ossification is irregular The patient is symptom free.

Because of this difference, Zeitlin[20] expressed the opinion that this latter group could be classed as an osteochondrosis while the designation of osteochondritis should be reserved for the smaller group that presented symptoms of a coxitis. In the more severe cases, which may even present the appearance of a sepsis, the differentiation from a true osteomyelitis of the ramus of the ischium may be most difficult It is made more difficult by the use of antibiotics that may completely cloud the clinical manifestations of the disease. In such instances, the use of the aspirating needle may be found indispensable.

In both the mild and the hyperacute cases, bed rest usually leads to gradual subsidence of the symptoms. For uncontrollable pain, Sanchis-Olmos has recommended the local injection of 1 per cent procaine directly into



FIG. 31 Ischiopubic osteochondritis. In the upper picture, the left side presents the appearance of ischiopubic osteochondritis during the acute phase. In the lower picture, healing has occurred, three months later (Reproduced from Durham, H A., Ischiopubic osteochondritis. *J Bone & Joint Surg 19* 937 1937)

he area of swelling Generally speaking surgery would not seem to be ndicated since healing with complete restoration of the continuity of the one has been repeatedly reported.

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CHAPTER 6

Fractures of the Ischium

IN THE OLDER literature, fractures of the ischium were considered rare. While exact figures are not available, some idea of their incidence may be gathered from the fact that in a series of 13 041 fractures collected from eight different hospitals, Gurlt[24] found only 108 fractures of the pelvis. In another series of 14,556 fractures collected by Stimson[8] at the New York Hospital during the years 1894 to 1905 only 75 involved the pelvis. In a study of 104 cases of fractures of the pelvis, Michaelis[18] found 51 fractures of the pubis, 20 of the ischium, 18 of the ilium, 10 of the acetabulum, and 4 of the sacrum.

These opinions as to incidence are not shared by more recent students. Key and Conwell[34] note that fractures of the pelvis are not rare may be gathered from the fact that Noland and Conwell report a series of 185 cases seen over a period of 12 years. They note further that fractures of the acetabulum are really fractures of the pelvis formerly considered a rare injury but with increasing use of the x ray the lesion is being diagnosed more frequently " Probably as a result of the more extensive use of the x ray and undoubtedly in consequence of increasing high-speed travel, the diagnosis of fractures of the pelvis is becoming not rare but undesirably common. This is especially true of the acetabulum, of which the ischium forms the largest part. In 500 cases of fracture of the pelvis reported in 1928 Westerborn[43] found 64 fractures of the acetabulum. In the same year Romani[6] reported on 139 cases of central fracture of the acetabulum.

While fractures of the acetabulum appear to be by all means the most common of the ischial fractures, fractures of the body the ramus, and even of the ischial spine have been reported.

FRACTURES OF THE ISCHIAL BODY

Exclusive of the adolescent avulsion fractures of the apophysis of the ischial tuberosity, fractures of the body are more common in middle age than in children or the aged. They occur more frequently in men than in women. Excluding gunshot wounds, which are notoriously unselective as to incidence and completely uninformative as to pathomechanics, fractures of the body of the ischium have usually been attributed to the effects of direct trauma. Because of its protected position under the mass of gluteal muscles the trauma is usually due to falls or blows directly against the ischium. Of six cases reported by Malgaigne[43] three resulted from a fall on the buttocks, one from a gunshot wound, one from an explosion and one during the course of an instrumental delivery. In this last case, the fracture resulted from the intrapelvic force exerted by the forceps in a woman who had suffered a double vertical pelvic fracture (Malgaigne type) some two years previously.

In 1881 Bennett[3] illustrated the findings in a fracture of the whole ischium discovered in the dissecting room. In 1909 Sharpe[64] presented the findings in a patient who while fishing in 1893 had fallen on his buttock. Disability was minimal but exacerbation of symptoms occurred in 1902. It was not, however, until 1909 after the introduction of the x ray that a definitive diagnosis of fracture of the ischium could be made with objective demonstration of the fracture site. In 1920 Haines[28] reported the case of a thirty three-year-old male, who suffered a bilateral fracture of the ischial tuberosities after falling from a wagon. The displacement was reduced per rectum with satisfactory healing. In 1921 Hodge[34] described a similar injury in a fifty seven-year-old male who fell forty feet from a tree, landing on his buttocks. Transitory paresis of the bowel and bladder ensued but recovery was complete in seven weeks. Ehalt[20] has described a case where, following a fall on the buttocks while skating, fracture of the ischiopubic junction extending into the acetabulum was observed. There was definite limitation of hip motion and the position of the fractured fragment had to be corrected by lateral traction. After three months immobilization good union with return of function occurred.

Despite the strength of the muscles attaching to the ischium, avulsion fractures of the body or the tuberosity seem to occur but rarely in the adult. Nevertheless, in 1778 Maret[45] reported the occurrence in a pregnant woman of an "intrapartem fracture of the tuber ischii during the course of a strong labor pain." Bell[2] reported an interesting case in which fracture of the ischial tuberosity was attributed to muscular avulsion. The patient, a fifty-seven year-old male, fell on his right side but complained of immediate pain on the left side. There was limitation of motion in the left hip and

ecchymosis was confined to the left side where the fracture had occurred. Gilbert[34] described a still more startling case of fracture by muscular avulsion. The patient was cranking his automobile, which backfired. Though he had not been struck by the crank handle, he immediately complained of pain in the perineum and along the inner aspect of the right thigh. He was able to walk home and the following day drove his car to a medical consultation where a diagnosis of bilateral fracture of the ischium was made.

With respect to the pathology Malgaigne has noted that the ischium may "sometimes be separated almost entirely in front of the descending



FIG. 32 Avulsion fracture of the ischial tuberosity Only a small fragment of bone at the insertion of the hamstring muscles has been detached.

ramus of the pubis and posteriorly from the cotyloid cavity which remains intact, while sometimes it is only the tuberosity which is detached from the bone" (Figs. 32 and 33) Displacement of the fragment is minimal and is usually inward following the direction of the fracturing force Downward displacement is prevented by the attachment of the sacrotuberous ligament. Downward displacement would occur only if all the fibres were ruptured as in Jobert's case (gunshot wound)"

Depending on the severity of the injury there may be associated visceral injuries, such as injury to the scrotum, the urethra, or even the kidney These are, however uncommon in simple fractures of the body Transitory retention of the urine owing to hematoma from injury to the pudendal vessels or to reflex inhibition following injury to the pudendal nerves may

occur Sciatic radiation of pain and even sciatic nerve paralysis is not uncommon after these fractures.

Directly after the injury these patients complain of pain in the perineum, along the affected thigh, and occasionally along the distribution of the sciatic nerve Because of the weight bearing function of the ischium, sitting is excruciatingly painful Rectal palpation elicits sharply localized pain and occasionally crepitus can be elicited upon rectal palpation (DeValz[16]) A localized area of contusion and later ecchymosis over the buttock and down the thigh are almost invariably present.



FIG. 33 Complete fracture of the body of the ischium. Anteriorly separation has occurred at the ischiopubic junction. Posteriorly the body has been fractured just below the acetabulum, which remains intact.

While the diagnosis will probably not be overlooked in those patients who present the characteristic symptoms, the condition may exist with a minimal symptomatology Cotton,[14] who expressed the opinion that the diagnosis was not justified in the majority of instances, noted "at last in 1912 I have seen a case resulting from a sitting fall in a woman save for local soreness, no symptoms." In such instances, the x ray will definitely establish the diagnosis. However it must be admitted that in cases with little displacement the existence of a fissure fracture may well be overlooked despite the high degree of diagnostic accuracy the x ray makes possible

Active surgical intervention is not indicated. After simple bed rest and the subsidence of the acute symptoms, these patients are able to resume their normal activities with but little difficulty Healing occurs in about eight

weeks. Downward displacement of the fragment seldom occurs and, as in the cases of ischial apophysiolysis, does not warrant any effort at replacement. On the other hand excessive medial displacement of the fragment in a woman of childbearing age may justify attempts at outward displacement of the fragment, since narrowing of the pelvic outlet may prove to be a serious cause for dystocia. Such efforts should be made with the greatest gentleness and with conscious recognition of the fact that force sufficient to damage the wall of the rectum or vagina might serve to convert a simple into a compound fracture.

FRACTURE OF THE ISCHIAL SPINE

Fracture of the ischial spine appears to be of the greatest rarity Indeed, except for the report of Burman and Sinberg[4] no other reports of this lesion



FIG. 34 Fracture of the ischial spine associated with fracture of the sacrum. (Reproduced from Burman, M.L., and Sinberg S., Tear of the sacrospinous ligament. *Bull. Hosp Joint Dis 8 69 1947*)

could be found in the literature. Their patient was injured when the truck that he was driving was struck from the rear As a result of this impact, the patient was thrown forward, striking his chest against the steering wheel and his knees against the instrument panel. When seen more than a month after his injury the patient still complained of pain in the lower back and along the outer side of his left hip He walked with a definite hip and knee

limp Motions of the back and left hip were markedly restricted There was definite tenderness over the left side of the sacrum and along the course of the sacrospinous ligament A roentgenogram made on the same day disclosed a comminuted linear fracture of the left ischial spine extending into the pelvis, and a fracture of the left side of the sacrum at the point of origin of the sacrospinous ligament A later x ray disclosed detachment of a block of the sacrum in this area The patient was treated conservatively and three months after injury was able to return to light work though still complaining of pain in the left groin (Fig 34)

In a later communication Burman[7] reported a second case in which, in association with other injuries—fracture of the eleventh thoracic vertebra,

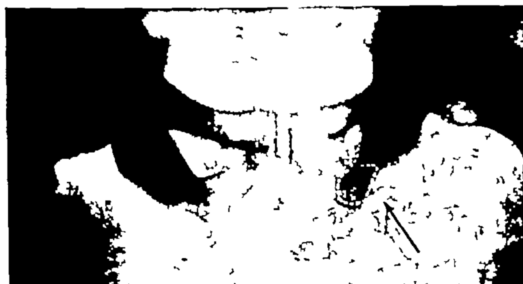


FIG. 35 Fracture of the ramus of the ischium attributed to excessive pull of the sacrotuberous ligament. (Reproduced from Burman, M., Tear of the sacrospinous and sacrotuberous ligaments. *J Bone & Joint Surg* 34A 331 1952.)

laceration of the urethra, fracture of both rami of the left pubis, and a fracture of the superior ramus of the right pubis—there was a fracture of the lower left side of the sacrum and an avulsion of the ischial spine Roentgenogram of the pelvis made one hundred ninety two days after the injury was reported as showing "nonunion of the avulsed ischial spine and the distally rotated fragment of the sacrum" This patient also was treated conservatively but continued to complain of pain and limitation of motion almost a year after his injury

While it does not seem likely that avulsion of the ischial spine would in itself establish a definite indication for surgical intervention, associated injury either to the nearby inferior gluteal artery or to the pudendal artery which winds around the base of the ischial spine to re-enter the pelvic

cavity might make necessary an urgent operation for the control hemorrhage.

FRACTURE OF THE ISCHIAL RAMUS

Fracture of the ischial ramus occurs not infrequently *in conjunction w more complicated fractures involving other parts of the pelvis.* Isola fracture of the ramus seems to be more common than fractures of the b or tuberosity and usually results from direct trauma. The site of fract is at the ischiopubic junction. In a series of eighty pelvic fractures, Jense noted eight ischial fractures, of which seven occurred at the ischiopu junction. Earlier reports on this subject had been made by Le Gros Clarl in 1859 by Peters[19] in 1903 and Jones[33] in 1943

Disturbance in urination appears to be a not uncommon complication the fractures by direct force. Rupture of the bladder and of the uret have been described. Urinary retention may be due to reflex inhibition to retroperitoneol hemorrhage

The diagnosis may be established by the history of a direct blow localiz tenderness made worse on extension and abduction of the thigh, limitat of motion of the hip, ecchymosis in the perineum, hip limp, and localiz *tenderness both on external and rectal examination.* Confusion with oth conditions that may present a similar symptomatology can be avoided or by means of x ray examination.

Displacement is *slight and except for the treatment of complicatio* nothing more than bed rest is required to insure healing of the fracture.

While fractures of the ramus result most frequently from direct violen *it has been reported as a result of indirect stress. Burman[7] described* a ca that he attributed to excessive pull of the sacrotuberous ligament (Fig 3

Stress fractures of the ischial ramus have appeared in the literature und the designation of "stress"or "march" fracture of the descending ramus the pubis or of the ischiopubic junction (Fig 36) The earliest such repo the exact details of which could not be verified, seems to have been ma by Cappelletti [9] in 1847 Another case was reported by Marchesi[44] in 191 Forcher Mayer[22] considered the condition as a typical sport injury fencers. It appears to have been seen often among soldier recruits by W helmi[67] and Brandt,[8] and has recently been again described by Jones Nickerson,[44] and Selakovich and Love[53]

Wachsmuth[63] expressed the opinion that the pathogenesis of the cond tion was to be sought in the antagonistic action of the adductor magnu which tends to extend the pelvis, and *the adductor brevis, longus,* and th gracilis, which tend to flex the pelvis. Henschen[29] considered the conditio as manifesting the same signs of fatigue as are to be seen in steel and oth

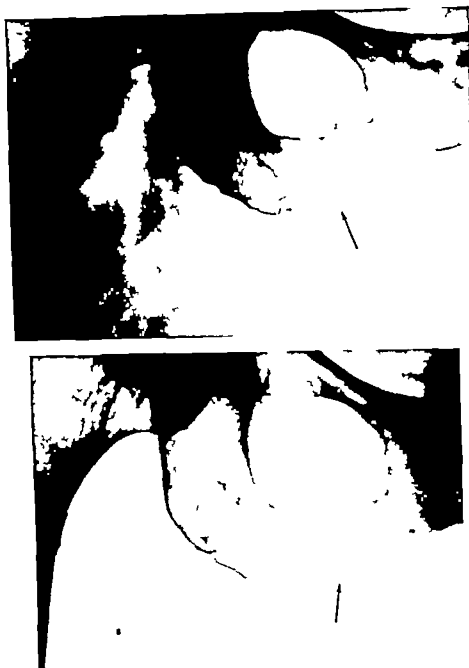


FIG. 36. Stress fracture of the ischial ramus. *Top* at the time of onset of symptoms, there was an area of radiolucency with a periosteal reaction at the junction of the descending ramus of the pubic and the ramus of the ischium. *Bottom* one year later when all symptoms had disappeared the radiolucent area had been reconstructed by new bone formation. (Courtesy of Dr A Friedman)

structural materials. He described four different stages in the course of the affection periosteal neuralgia, ossifying periostitis, rarefying osteitis, and finally fracture. Under excessive stress, weakening of the bone occurred as the result of a reorientation with a gliding away of the bone crystals at the site of stress. Where the stresses were not excessive or where the exercises

were properly conducted, new bone crystals were deposited in accordance with Roux's law of atrophy and hypertrophy. Where the stress was sufficiently reduced or where the periosteal reaction was sufficiently great, fracture did not occur.

Corresponding with this concept, histological sections through the area of stress fracture revealed lacunar resorption of the bone trabeculae, localized areas of necrosis, periosteal thickening and scattered bone trabeculae surrounded by newly deposited osteoid tissue. In many respects, it presented the picture of bone formation seen in normal endochondral ossification. It is interesting to note that these phenomena occur precisely at the ischiopubic junction and that their x ray presentation may be identical with that seen in ischiopubic osteochondritis of children.

Characteristically, the condition develops in persons who, having previously led a sedentary life, are suddenly required to engage in prolonged and strenuous activities. This has been observed in overzealous training for athletic activity and more particularly among young military recruits.

The first symptom, pain in the perineal, ischial, inguinal or medial femoral regions, is noted some weeks or months after the onset of the activity. The pain is progressive and is made worse by persistence in walking, running or combat exercise. A swelling may develop in the ischiopubic region but is not usually associated with any limitation of motion in the hip. Examination discloses tenderness on palpation in the perineum over the ischiopubic junction. The roentgenogram is characterized by haziness at the ischiopubic junction, later periosteal proliferation, and ultimately fracture at this site.

Treatment is directed toward bed rest during the acute phase. Healing invariably takes place without any residual disability. The appearance of the condition may be avoided by varying and carefully selecting the exercises to which the recruit is subject.

FRACTURES OF THE ACETABULUM

Fractures of the ischial portion of the acetabular cavity have been the subject of many studies and have appeared in the literature under various headings, such as intrapelvic luxation of the femoral head, central dislocations of the femur, "dashboard injuries" of the acetabulum, and ischioacetabular fractures. Though they are said to have been recognized by Paul Aegmetus and Ambroise Paré, Callisen is credited with having made the first report of such a case in 1778. He described the exact extent of the fracture and called attention to the value of rectal palpation in localizing the site of the lesion.

A not inconsiderable part of the confusion that surrounds the subject

has arisen from attempts at classification of the various fractures on the basis of the almost innumerable combination of fracture lines that may be present. In the interest of brevity it seems justifiable to divide fractures of the acetabulum into three different types (1) fractures of the rim, the so-called dashboard fracture (2) central fractures of the acetabular floor and (3) ischioacetabular fractures.

FRACTURES OF THE ACETABULAR RIM

Fractures of the rim, actually fractures of the rim with dislocation of the femoral head, are usually the result of direct impact, and have



FIG. 37 Fracture of the acetabular rim with posterior dislocation of the femoral head, so-called dashboard fracture.

become noticeably more frequent since the advent of high speed locomotion. Formerly fractures of the superior rim, the result of landing on the extended legs after a fall were more common. At present, fractures of the posterior rim that would result from backward propulsion of the flexed femora against the ischial portion of the rim are more prevalent (Fig 37) It is in consequence of the frequency with which this mechanism operates in patients whose legs, in the seated position, strike the automobile dashboard (instrument panel) that the fracture has received the designation of dashboard fracture.

The diagnosis may be suspected from the nature of the injury If not

unconscious, the patient complains of severe pain and complete func incompetence of the affected limb In contradistinction to the pc assumed after fracture of the femoral neck, the limb is usually h flexion, adduction, and internal rotation. (Rarely the limb may b ternally rotated.) Corresponding with the upward dislocation, the trochanter lies above Nelaton's line, and the distance from the an superior spine to the homolateral internal malleolus is less on the af than on the normal side. Active motion of the thigh and passive abd extension and external rotation are impossible.

Definite diagnosis can be established only by means of the x ray this is not, however always simple and a small fragment hidden behin femoral head may be easily overlooked. Wherever there is serious as to the actual condition, x rays should be made with different exp and preferably stereoscopically

Treatment is directed toward early reduction of the dislocation, delay of even a few days markedly increases the difficulty of redu *Delay of as much as six weeks may render reduction impossible* and if possible, useless, because of the damage to the head as a result of ci tory impairment. All those who have studied these cases are in com agreement that early reduction is of the utmost importance. Stewar *Milford*[15] *even go so far as to state*

> manipulative reduction should take precedence over the treatment other skeletal injuries. There is a common misconception that a patien is suffering from severe injury and shock is in too critical condition fo administration of anaesthesia. A short acting anaesthesia is not contraindica the patient's air passages are open and if reduction can be accomplished in minutes. However the reduction of a dislocated hip always tends to relieve and is often the key to recovery Open reduction of the acetabulum be delayed provided the dislocation of the femoral head has been reduced.

Reduction depends upon relaxation of the y-shaped ligament of Big by flexion and internal rotation. It is stated that this principle was emph as early as 1670 and was the routine practice of Smith as early as Bigelow[4] *himself admits the priority of Smith in respect to the use of fle* and all the currently employed methods of reduction, that of Allis Bigelow and of Stimson[16] depend upon this primary maneuver With hip in flexion, the femoral head is then pushed or pulled back into acetabular cavity

Once the reduction has been accomplished, further procedure will pend upon the condition of the rim and the condition of the patien there is little displacement, the thigh may be immobilized in abduction plaster of Paris spica *for a minimum of six weeks*, or until there is s assurance that early union has taken place. Excessive immobilization

be avoided as tending to produce stiffness in the hip or flattening of the head Equally satisfactory results may be obtained by immobilizing the limb in balanced traction to overcome the pull of the pelvitrochanteric muscles. Motion without weight bearing should be encouraged immediately but under no circumstances should weight bearing be permitted before firm union can be demonstrated. This may take as long as four to six months



FIG. 38 Screw fixation of fractured acetabular rim. (Courtesy of Dr O Kestler)

but is a restriction well worthwhile, if the possibility of a severe traumatic arthritis of the hip can be minimized

If there is any displacement of the rim fragment so that the stability of the reduction is thereby brought into question, operative fixation of the fragment by means of screws is indicated (Fig 38) Where the fragment is of the superior margin, it may be approached by the anterior iliofemoral incision. Where the fragment involves primarily the posterior margin approach is best made through the posterior iliofemoral incision. If the margin is so fragmented that the possibility of screw fixation is excluded, it is probably best to forego any attempt at reconstruction of the glenoidal rim

and to treat the condition as an old congenital dislocation by means of a pelvic support osteotomy of the type described by Schanz.

Indeed, it may be questioned whether this may not be the best form of therapy in all such cases. Despite Campbell's statement to the contrary[9] even satisfactory reduction of the head and replacement of the fractured fragment does not insure complete functional rehabilitation. Simple dislocation of the head without fracture of the acetabulum as well as simple fracture without dislocation may lead to a distressingly high percentage of late traumatic arthritis of the hip. In a series of twenty-two such cases studied by Thompson and Epstein[16] there were no "excellent" results (i.e., those in which there was normal restoration of function). Sixteen of these twenty two cases were treated by closed reductions. Of these, "good" results were observed in only seven while in the other nine the results were "fair" or poor. In all seven cases, the dislocations were reduced within the first twenty four hours, the average time of weight bearing was four months. The results in "the six cases treated by open reduction were either fair or poor. Though these figures would seem to contraindicate attempts at open operation, the authors express the opinion that while this series does not prove that open operation is contraindicated, it does demonstrate the relative effectiveness of early closed reduction, and that if performed at all, operation should be carried out promptly.

Similar conclusions though with somewhat better results were reported by Stewart and Milford, who attempted to evaluate their results with respect to the severity of the injury and the time elapsed before reduction. Of 77 cases in which there were rim fractures, 5 died following manipulation. In 69 posterior rim fractures with posterior dislocation in which closed manipulative reduction was used, 25 were Grade 1 (simple dislocation with no fracture) 33 were Grade 2 (comminuted rim fracture with mild dislocation) 9 were Grade 3 (comminuted rim fracture with marked intrapelvic protrusion) and 2 were of Grade 4 (associated fracture of the femoral head or neck). Nineteen cases of the 25 Grade 1 group gave excellent or good results (76 per cent). Fourteen cases of the 33 Grade 2 group gave excellent or good results (42.4 per cent). Two cases of the 9 Grade 3 group gave excellent or good results (22.3 per cent). One of the Grade 4 group gave excellent or good results (50 per cent). Of the 67 posterior dislocations 29 cases belonging to Grades 1, 2 and 3 were reduced within the first 12 hours with 26 excellent or good results (89.6 per cent). Thirteen cases of Grades 1, 2 and 3 were reduced between the thirteenth and twenty fourth hours with 10 excellent or good results (77 per cent). All those reduced more than 24 hours after injury gave fair or poor results.

Of 33 patients in whom operation was undertaken 5 were submitted to primary reconstructive measures and 27 were submitted to open reduction.

Only 7 of these gave excellent or good results (25.5 per cent). Though this would seem to be conclusively against open operation, consideration must be given to the fact that these cases were operated upon at an average of 33 days after injury and were obviously of the more serious group. This would seem to be substantiated by the fact that in 5 posterior dislocations, of which 4 were reduced by open operation within 24 hours and 1 by closed reduction followed by open fixation one week later, 2 excellent and 3 good results were obtained.

In summary, it would appear that the extent of the injury is not as important in the ultimate outcome of the case as is the time that has elapsed before reduction of the head is obtained. If reduced within the first 24 hours, the results appear to be fairly satisfactory. If unreduced for more than 24 hours, the results appear to be at best only fair regardless of the treatment or the severity of the lesion. It is this which justifies the opinion that reduction is of prime consideration even in the face of concomitant injuries.

CENTRAL FRACTURES OF THE ACETABULUM

Central, perforating, or floor fractures of the acetabulum appear to be definitely less common than either rim fractures or the ischioacetabular fractures from which they should be carefully differentiated. There is considerable confusion as to the exact definition of "central" fractures. Westerborn[44] reported a series of 500 pelvic fractures in which the acetabular floor was fractured in 64, in which there was intrapelvic protrusion of the head in 21. Similarly Romani[41] collected 135 such cases from the literature and added 4 cases of his own. In both instances, it appears that it was the intrapelvic protrusion of the head rather than the nature of the fracture that was emphasized. Vaughan[41] insisted that only those be called "central" in which the head actually penetrated the floor of the acetabulum without rim fracture and in which the edges of the acetabular fragments surrounded the femoral neck like a collar. He particularly called attention to the fact that neither intrapelvic protrusion of the femoral head nor medial displacement of the medial wall of the pelvis could be considered as true central or perforating fractures of the acetabulum.

There can be no quarrel with Vaughan's definition as regards the most severe cases of central fracture, but it would appear to be too exclusive of the milder cases in which undoubted fracture of the acetabular floor without or with but slight penetration of the pelvis has occurred. On the other hand, since intrapelvic protrusion is possible in cases of ischioacetabular fracture, it must be admitted that the mere intrapelvic protrusion of the femoral head does not establish the existence of a central floor fracture. While the use of the term "central dislocation" is useful in differentiating fractures of

the acetabular floor from those in which there is posterior or superior dislocation as a result of the rim fracture it is somewhat confusing when it is desired to distinguish between true fractures of the floor alone and those that involve the acetabulum and other parts of the pelvic wall. Henschen attempted to clarify the issue by referring to those intrapelvic protrusions in which the femoral head actually penetrated the floor of the acetabulum as 'central while referring to those in which the femoral head followed the medially dislocated inner wall of the pelvic as "*Eccentric*" dislocations.

Fanton[11] observed that fracture of the base of the acetabulum is more frequent than is suspected especially the mild forms often pass unrecognized and are commonly misapprehended as contusions of the hip." In support of this thesis Dupont[18] reported two cases seen in Broca's clinic one complained of mild pain on pressure over the trochanter and manifested the symptoms of a mild plastic arthritis for a period of five months. The other a young soldier was kicked by a mule. With the exception of localised pain over the horizontal ramus of the pubis, on rectal examination, all signs and symptoms were minimal. The x ray in both revealed a fracture of the acetabulum

Kontorowitch[24] reported the case of a man of seventy who after a fall on his side was unable to rise There was some ecchymosis of the scrotum. Though the trochanter was depressed there was no tenderness on percussion over the trochanter Except for abduction and adduction, motions of the hip were normal and rectal examination was negative. The x-ray nevertheless disclosed a fragment of bone from the acetabulum projecting into the pelvic cavity

Central fractures may occur at all ages. Thevenot[30] states, " fracture of the acetabulum may easily occur in the infant. The femoral neck is strong and when the trochanter is struck, the head is driven into the acetabulum and enforces a yielding of the cotyloid cavity The y-shaped cartilage acts as a sort of buffer and permits some play between the different parts of the pelvis. It yields gradually and becomes progressively worse, especially in its lower vertical segment." Dupuytren[19] is quoted to the effect that in youth the force which is directed against the center of the cotyloid cavity may separate the parts of which the immediate bone is composed and whose point of union is the center of the cavity "

Traumatic fractures of the acetabulum are seen more frequently in men than in women. In 53 cases reported by Delannoy[13] 41 were found in males and only 12 in females.

Acetabular fractures are usually the result of external trauma. They have been described as occurring after falls on the feet or knees, falls on the opposite shoulder falls on the sacrum, the trochanter or the ischium, or falls or blows against the anterior curve of the pubic arch This type of

case is usually unilateral but recently Camera reported a bilateral case resulting from a street fall Bilateral cases, the consequences of convulsive therapy have been reported by Ligas,[41] Lingley and Robbins,[42] Haines,[2?] Kalinowsky and Hoch,[24] and others. Kalinowsky notes

> that this otherwise rare type of fracture is not infrequently seen in electroshock therapy It can be explained only by the sudden contracture of muscles which pull the head of the femur towards the pelvis. The mechanism of this fracture seems to be the same as that of fractures of the neck of the femur The impact of certain adductor muscles either compresses the femur so that a fracture occurs or if the acetabulum is not strong enough to resist, it is fractured and the head of the femur is driven into the pelvic cavity

A great many experimental studies have been undertaken in the effort to explain the pathomechanics of these fractures. In sixteen cadaver experiments performed by Virevaux[43] the trochanter was struck by a five kilogram hammer but acetabular fractures resulted in only a few instances and of those only one was central Féré[22] let cadavers fall on their ischia with the thighs flexed Horizontal fractures of the type described by Walther but no central fractures of the acetabulum were obtained Thevenot failed to produce central fractures of the acetabulum until the bony femoral neck was replaced by an artificial wooden prosthesis and then only when the legs were in extension. When the legs were in flexion, blows against the trochanter yielded horizontal fractures of the ischioacetabular type.

It may well be that the failure to achieve consistent results experimentally was due to the inadequacy of the force employed. King and Richards[34] state that " the tremendous force with which a person may be thrown against the instrument panel (or against the back of the front seat if he is riding in the rear seat) is well illustrated as follows the kinetic energy of a 150 pound body moving at 45 miles per hour is 10 200 foot pounds. In bringing this moving body to rest the same amount of energy must be expended (10 200 foot pounds is equivalent to five tons falling one foot.)"

Because of the magnitude of the force required to produce central fractures of the acetabulum, serious injury to the pelvic viscera are not infrequently associated with this fracture Urinary retention is an almost constant complication, but actual rupture of the urethra, the bladder the kidney as well as injury to the rectum, obturator vessels, nerves, and even the sciatic nerve have been reported. These injuries may be serious enough to jeopardize life and their emergency treatment pre-empts any attention to the fracture itself

In the case of a true central fracture of the acetabulum with intrapelvic protrusion of the femoral head, the diagnosis is usually made without too much difficulty The patients complain of severe pain, inability to bear

weight and marked limitation of motion, especially of abduction. This is due to the abutment of the great trochanter against the acetabular rim. Large ecchymosis in the region of the inguinal ligament (*Lossen's* sign) and occasionally a nummular ecchymosis at the base of the scrotum (*Destot's* sign) may be seen. There is tenderness on percussion over the great trochanter that is definitely closer to the pubic spine on the affected side than on the unaffected side (*Roux's* sign) (Fig 39) Though the leg may lie in

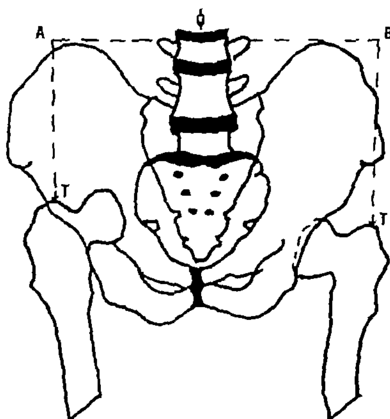


Fig. 39 Roux's sign. The distance from the tip of the trochanter to the mid-line of the body is less on the side of fracture than on the normal side.

internal rotation, Vaughan found external rotation most common, so that at first sight the condition resembles that seen in fractures of the femoral neck. There is apparent shortening of the affected limb. On rectal examination crepitus and the inward projection of the femoral head (*Earle's* sign) may be felt.

In the advanced cases the roentgenogram affords a ready and dependable means of diagnosis. The femoral head uncovered by bone projects into the pelvic cavity. In an unusual case reported by Vacquez[44] a circular portion of the acetabular floor was displaced into the pelvis but without any dislocation of the femoral head.

In the mild case, the x ray may show only indistinct linear fracture lines without any evidence of inward projection of the femoral head Such cases may present only minimal signs localized pain over the trochanter, localized pain on rectal examination, occasional ecchymosis in the scrotal or inguinal region and some limitation of motion. These are the so-called "silent cases that may justifiably be mistaken for contusions. However the inability or



FIG. 40 Healed central fracture of the acetabulum. The entire floor of the acetabulum has been displaced into the pelvis by the femoral head, which protrudes beyond the arcuate line.

the impossibility of definitely establishing the diagnosis does not preclude its existence.

Henschen reported the case of a woman aged twenty five months pregnant, who fell a distance of four feet off a wagon landing on her right side. She complained of great pain, inability to walk, and had difficulty on urination for a period of three days. All other signs including rectal and x ray examination were negative and after six weeks hospitalization the patient was permitted to return home Because of limp and progressive pain, the patient returned to the hospital and at this time a large bony mass projecting from the inner wall of the pelvis was felt both on rectal and vaginal

examination. The x ray disclosed the femoral head protruding into the pelvis and covered by a large mass of callus. This led to definite difficulty in delivery and the child was born with a cranial depression corresponding to the bony mass on the inner pelvic wall. Henschen attributed the protrusion to *the fact that the patient had been permitted to walk before firm union had* occurred with resultant gradual yielding of the pelvic wall and progressive deposition of excess callus.

Treatment will vary with the severity of the lesion. In the mild case where there is fracture without central dislocation of the femoral head, bed rest with traction to overcome the force of the pelvi trochanteric muscles will suffice. Weight bearing should be interdicted for at least four months or until there is reasonable assurance that firm union has occurred. In women of childbearing age, it is particularly important to prevent the possibility of gradual narrowing of the pelvic outlet by inward protrusion of the femoral head (Figs. 40 and 41). *In cases where there is inward* protrusion of the pelvic wall without actual penetration of the floor lateral traction may be applied to the great trochanter (Camera) or the pelvic wall may be pulled out by the turnbuckle method described by Jahss[11] and recommended by Dudgeon[17] (Figs. 45 and 46). *In cases in which the acetabular rim has remained unbroken*, Whitman's method of impinging the trochanter against the ribs and then levering the head out of the acetabulum has been successfully performed by Kleinberg[18] and Coley.[19]



FIG. 41 Intrapelvic protrusion of the acetabulum (Otto's pelvis) following healing of a central fracture. The tip of the great trochanter impinges against the acetabular margin and there is a marked reduction in the inter tuberosity distance

The most severe cases where the head penetrates the floor of the acetabulum and the fractured fragments encircle the neck lateral to the capital enlargement are not amenable to the more conservative closed methods of treatment. In such cases, Vaughan advised prompt resort to open *operation. The operation is complicated and shocking.* In one such case Vaughan reported a satisfactory outcome despite infection of the wound. The prognosis in such cases is serious. In 26 patients with unquestioned central fracture of the acetabulum that Vaughan collected from the litera

ture 8 died. In the other 18 patients who lived the functional result was good in only 3 The rest presented evidence of pain and limitation of motion owing to osteoarthritic changes in the hip In an analysis of central fracture of the acetabulum Stewart and Milford noted that 8 of 10 patients reduced by closed methods within the first 12 hours showed good or excellent results. One patient, Grade 2 reduced within the first 24 hours, had an excellent result while another Grade 3 had a poor result Six patients treated after 48 hours all showed poor results. Of 4 treated surgically only 1 showed a good result, 1 was fair and 2 were poor Five of the 18 patients developed a vascular necrosis with later osteoarthritic manifestations.

Where severe osteoarthritis is the final outcome therapy must be directed toward its relief As in other forms of arthritis, treatment is possible by means of arthrodesis, by prothetic replacement of the femoral head by vitallium cup arthroplasty or by the resection angulation operation.

ISCHIOACETABULAR FRACTURES

In 1891 Walther[illegible] who had been attempting experimentally to reproduce "central" fractures of the acetabulum described a fracture that has been called "ischioacetabular "In this condition, the ischium as a whole is pushed and tilted inward as a result of a fracture line which passes through the ischio-pubic junction, the acetabular cavity and the ischial spine (Fig 42) Though not common, it occurs more frequently than is suspected and has been frequently erroneously included in statistical studies of central fractures of the acetabulum." Of the six cases reported by Westerborn[illegible] as "central dislocation of the femoral head," five are clearly of the type that must be described as ischioacetabular Gioia,[27] Leinati,[illegible] Milch,[47] and others have reported cases under the more specific designation of ischioacetabular fractures.

This fracture, like other extensive pelvic fractures, may be associated with injuries to the neighboring soft tissues, the bladder the urethra or the bowel. Injuries to the obturator nerve and paralytic phenomena from injury to the sciatic nerve are not uncommon. Either the peroneal or the tibial or both portions of this nerve may be involved. The nerve may actually be partially or completely severed but most frequently the paralytic phenomena are due to traction on the nerve at the time of injury Recovery may be partial or complete

Usually the diagnosis of this severe type of pelvic injury is apparent but it may appear in such mild guise as to be mistaken for a contusion of the hip

Typically the picture is that of a marked disability following a characteristic history of injury The leg is usually held in flexion, abduction, and

external rotation. Active motion is completely inhibited and passive motion is markedly limited. There is *tenderness* on percussion and palpation over the trochanter. Within a short time of the injury swelling resulting from hemorrhage may be noted in the region of the crural canal (*Loessen's* sign) at the base of the scrotum (*Destot's* sign) or along the pubic ramus



Fig. 42. Ischioacetabular (Walther's) fracture. The fracture line extends from the ischiopubic junction through the floor of the acetabulum to the ischial spine. The entire inner wall of the pelvis has been displaced medially, leading to a true ischium varum.

(*Delannoy's* sign). Corresponding to the degree of hemorrhage, there may be a sense of fullness in the iliac fossa. Depending on the degree to which there is intrapelvic protrusion of the femoral head, the fascia between the ilium and the great trochanter will be relaxed (*Allis'* sign) and the distance from the great trochanter to the pubic spine will be diminished as compared with the opposite side (*Roux's* sign). Rectal examination for the determination of crepitus or intrapelvic protrusion of the medial wall of the

pelvis (*Earle's* sign) should never be neglected. Though the trochanter may lie above Nelaton's line, this has no pathognomonic significance (Fig 7) It is a purely geometrical relationship and merely indicates some abnormality in the region between the trochanter and the pelvic wall. The court of last and possibly of first resort is the x ray

The treatment of these cases is most unsatisfactory The prognosis is not



FIG. 43 Old, healed ischioacetabular fracture, with production of Otto type of pelvis. There were no signs of hip joint involvement, but the patient presented signs of a permanent sciatic nerve paralysis

good In 16 cases reviewed by Rahman[14] only 1 case had a complete functional recovery while in the other 15 functional loss of 15 per cent to 50 per cent was recorded. Cottalorda[11] estimated the over all loss of function at between 30 and 40 per cent. Of 139 cases studied by Romani there are only 29 cures. Twenty-one patients died and 77 had marked functional loss. On the other hand, Stewart and Milford reported that of 18 central fracture dislocations of all grades treated by closed reduction, 2 were excellent, 7 were good, 1 was fair and 1 was poor Of the 4 central fracture dislocations



Fig. 44 Old healed ischioacetabular fracture. There is a true ischium varum on the left side without any evidence of arthritis of the hip. There was a permanent sciatic nerve paralysis.

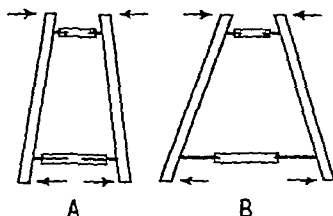


Fig. 45 The Jahss method of applying lateral traction or compression to the pelvis. Two long leg p[...] are applied and are held together by turnbuckles. By extending the lower [...] lowing the upper pressure is exerted [...] side of the femora, tending to [...] walls of the pelvis as in the treatment of the [...]. By extending the [...] and [...] er pressure is [...] [...] femur thus tending [...] lateral [...] pelvis by traction al[...] fem[...] of value in the fract[...]. (Reproduced [...] Inj[...]. Am. J. Surg.

treated surgically 1 was good, 1 fair and 2 were poor Where there is no marked inward displacement of the medial pelvic wall prolonged bed rest without weight bearing until there is evidence of firm bony union is essential (Figs. 43 and 44) Where there is medial displacement of the pelvic wall, efforts must be made to reduce the fragments to minimize the tendency toward osteoarthritis and, in the case of females of childbearing age, to avoid the possibility of narrowing the pelvic outlet In individual cases, reduction

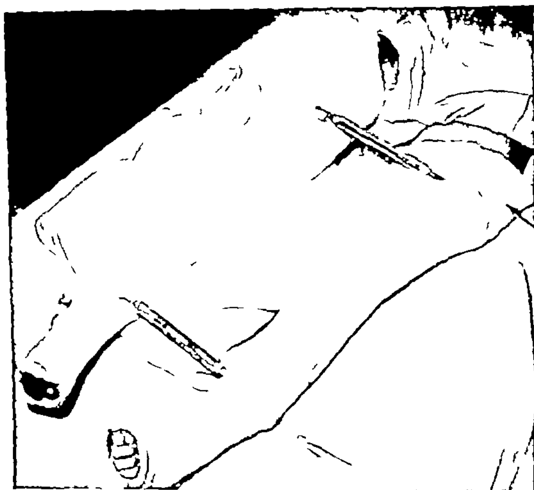


Fig. 46. Method of applying the Jahss turnbuckle cast

has been accomplished by a variety of methods, all of which employ the principle of lateral traction on the *femur*

As in central fractures of the acetabulum, lateral traction may be exerted by a sling around the upper end of the thigh or by adducting the legs over a bolster placed between the upper ends of the thigh (Ollier and Virevaux) This principle was employed by Jahss[11] when he incorporated double turn buckles in leg casts. By extending the upper turnbuckle and closing the lower turnbuckle, the upper ends of the thigh were forced outward and exerted a lateral force on the fracture through the pelvifemoral ligaments

(Figs 45 and 46) Where such methods are unsuccessful, lateral traction may be exerted through the insertion of wires, screws, or bands into the great trochanter Replacement of the fractured fragments by manipulation through the rectum is seductively simple and has been accomplished successfully It is, however a highly dangerous method since puncture of the rectal mucosa may lead to infection of the hematoma, of the parietal tissues, and of the fracture itself

It is far safer even if more trying on the patient, to enter the pelvis retroperitoneally through an inguinal incision as suggested by König This method must, of course be followed by continuous lateral traction to eliminate the medial drive imparted to the femoral head by the pelvitrochanteric muscles. In one instance reported by Levine[44] actual plating of the fractured fragments was successfully accomplished Unprotected weight bearing should be avoided until firm healing has taken place but both active and passive motion should be encouraged early

In six instances, in which the extent of the acetabular injury indicated the impossibility of a satisfactory functional return, Westerborn[64] performed primary vitallium cup arthroplasty "In five of the six patients the results have been encouraging" In other instances primary arthrodesis, primary arthroplastic procedures, or reconstruction operations may have to be considered.

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CHAPTER 7

Ischial Apophysiolysis

ISCHIAL APOPHYSIOLYSIS is an avulsion fracture of the apophysis of the ischial tuberosity It occurs in adolescents before the age of eighteen to twenty five years, at which time closure of the epiphyseal line normally takes place. The condition is so characteristic as regards modes of onset, symptomatology roentgenographic appearance, and clinical course that it must be considered as constituting a specific clinical syndrome.

INCIDENCE

Though this condition must have occurred before its earliest description, in all probability it was then, even as now all too frequently casually dismissed as being a mild muscle tear of the type commonly called "charley horse. Historically it is interesting to note that in his treatise on fractures and dislocations, Malgaigne[7] observed that the ischium may sometimes be separated almost entirely in front of the descending ramus of the pubic and posteriorly from the cotyloid cavity which remains intact, while sometimes it is only the tuberosity which is detached from the bone." Although he failed to make any conclusive statement as to the existence of adolescent apophysiolysis, he noted that after fracture in adults "it might be presumed that the powerful muscles inserted into the tuberosity would draw down the detached portion if all the fibres were ruptured as in Jobert's case." From the literature at present available, Poland[11] seems to have been the first to call specific attention to the fact that apophyseal separation of the ischial tuberosity could occur In 1898 he noted t[illegible] R. W Parker has observed a separation of the epiphysis in th[illegible] with suppuration following a kick and the author has seen a [illegible]le the result of direct violence.

Neither of these observers, however, can be credited with having described the typical picture of adolescent apophysiolysis resulting from indirect violence. As accurately as can be established at the present time, Berry[1] was the first to report such a case. His patient was a male of twenty-three who, at the age of twenty, while running in a foot race, suddenly felt "something snap" in his buttock and fell to the ground. He complained of severe and progressive pain that rendered standing, walking, sitting in a hard chair, or forward bending impossible. Roentgenographic examination disclosed that the large mass that could be felt below the ischial tuberosity



FIG. 47. The crescentic shadow of the completely avulsed ischial apophysis is seen lying just below the femoral neck. (Reproduced from Milch, H. Avulsion fracture of the tuberosity of the ischium. *J Bone & Joint Surg* 8:832, 1926.)

was an ununited portion of the ischium. This was removed with great relief to the patient.

In 1926, Milch[1] reported the second case. This was the first instance in which the symptomatology of the acute phase of the condition was observed, and in which attention was particularly directed to the characteristic x-ray appearance. The patient, a young girl of eleven, had suffered an injury to the right buttock while doing a split during practice for a dance. In attempting to regain the upright position, she "felt something slip" in this region, fell back, and was unable to arise. The pain radiated along the course of the hamstring muscles and both sitting and standing were painful. A diagnosis of muscle sprain was made and bed rest was advised. After several days the pain subsided, but on leaving her bed, limp and an apparent lengthening of the affected limb brought her for consultation.

Examination disclosed a mild limp slight unsteadiness in gait, and a marked limitation in motion of the right hip Adduction, internal rotation, and extension of the right hip were painful. Against resistance, extension of the right hip was definitely diminished as compared with the left, unaffected hip With the knee flexed the hip could be normally flexed, but with the knee extended there was definite increase in pain and limitation of flexion. Direct pressure over the tuberosity was painless, but rectal palpation of the tuberosity and sacrotuberous ligament elicited complaints of sharp pain.



FIG. 48 Incompletely avulsed ischial apophysis appears as a peri-ischial shadow lying just below the body of the ischium on the right side.

The roentgenogram revealed the pathognomonic crescentic shadow of the avulsed ischial apophysis (Figs. 47 and 48) Under simple bed rest, there was complete abatement of pain so that the patient did not return for follow up x ray examination. Because of the inability to follow this case to its definitive end result, the clinical picture of the acute phase was described along with signs that must be considered as pathognomonic of the condition. In the years that followed this earlier presentation, other cases have appeared in the English and Continental literature with increasing frequency These in conjunction with two additional cases in which it was possible to follow the patients roentgenographically up to the time of complete healing permitted a definitive description of the syndrome (Milch[11])

Characteristically the condition occurs in patients below the age of

twenty five the upper age limit for complete ossification of the ischial apophysis. It has been described as rare though this is open to question. It is difficult to draw any conclusions as to its exact incidence. McLaughlin[9] noted that in the files of the Presbyterian Hospital, New York City only three cases of avulsion by muscle action could be found At the same time Caffey[3] stated that he had seen three similar cases that were not reported. Though this would seem to document the relative rarity of the condition as indicated by the paucity of cases reported in the literature, the increasing number of such reports suggests that many more such instances could be



FIG. 49 Bilateral ischial apophysiolysis. On the right side there is some evidence of attempted healing On the left side the apophysis is clearly ununited (Reproduced from Gutschank, A., Case of bilateral avulsion fracture of the ischial tuberosity *Arch Orthop u Unfall-Chir 33* 256, 1933)

found in the unreported files of other roentgenologists. Many more undoubtedly will be found as soon as the possibility of its occurrence is recognized and all cases of "muscle sprains in the gluteal region are routinely submitted to x ray examination.

The condition is seen predominantly in males and only two female cases have been reported in the literature (Milch[11]) In both of these individuals, apophysiolysis developed under circumstances of strenuous activity analogous to those known to have precipitated the symptoms in the males. It seems, therefore, reasonable to attribute the higher incidence in males to their greater participation in sport or other physical activity and not to any genetically determined factor

With the exception of the case reported by Gutschank[3] all the instances thus far reported have been unilateral Gutschank s patient was a male who

presented all the signs of a right sided avulsion of the ischial apophysis. The roentgenogram, however unexpectedly revealed the existence of an identical lesion on the *left side* (Fig 49) In the absence of any history of recent trauma or any *localizing* symptoms, it was presumed that this represented an antecedent previously unrecognized avulsion.

In the great majority of males the left side has been involved, while in *females* the right side was affected This, too would seem to bespeak some *peculiarity* in the use of the left lower extremity by right handed males *rather than* any predilection for the right side in the females. In all cases, the influence of trauma and specifically of excessive tension *on the hamstring* muscles has been reported. All the cases were preceded by strenuous activity such as football playing running jumping or acrobatic dancing

It is unfortunate that in Gutschank s case there was an associated earlier separation of the upper humeral epiphysis that led to the tentative suggestion of an underlying endocrine pathology In two other cases, one reported by McMaster[8] and another by Scott,[13] the designation epiphysitis" was used. McMaster however was affirmative in denying any endocrine basis and Scott, whose patient showed a basal metabolic rate of minus 24 per cent, stated "There were no outstanding symptoms or signs to substantiate a diagnosis of frank hypothyroidism other than sparse hair distribution and a consistently slow pulse '

The assumption and even the suggestion of an underlying endocrine disturbance as the basis of the condition would seem totally unwarranted. The involvement of only one other epiphysis, the absence of any of the roentgenographic evidence typical of generalized epiphysitis or epiphyseal disturbance, and its nonappearance in all the other cases would not justify any serious consideration of this as an etiological factor By and large, it may be stated categorically that the condition is of traumatic origin and results from muscular violence within the age limits of closure of the ischial apophysis.

DYNAMICS

The pathomechanics of the condition that appear characteristic of the erect bipedal stance of the human may be explained on an analysis of the structural design of the pelvis. For the purpose of analysis, the adult pelvis may be considered as consisting of two arched lever arms united anteriorly at the symphysis pubis and articulating posteriorly with the sacrum. Each hemipelvis acts as a lever of the first class with the femoral head as the fulcrum. The anterior portion of the bony lever is formed by the descending ramus of the pubis and the anterior portion of the ischial ramus. The posterior portion of the lever is formed by the body of the ischium and the posterior part of the ischial ramus. After closure of the ischial apophysis,

dynamic balance of the pelvis over the femoral fulcrum may be visualized as maintained by one force couple acting upon the anterior extremity of the lever and by another acting oppositely at its posterior end (Fig 50) The anterior force couple is represented by (*1*) the pubofemoral and iliopsoas muscles, which tend to tilt the pelvis downward, and (2) the muscles of the anterior abdominal wall, which tend to tilt the pelvis upward The posterior force couple consists of (*3*) the lumbar and oblique abdominal muscles, which act to tilt the pelvis downward, and (*4*) the glutei and the hamstring muscles, which assist the anterior extensors in tilting the pelvis upward.

In patients under the age of apophyseal closure, the dynamic analysis is entirely different. The mere interposition of the apophyseal plate converts

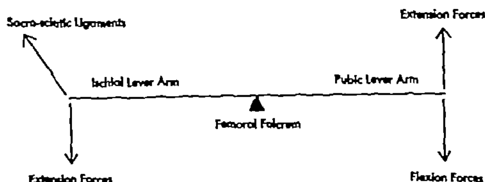


FIG. 50. Dynamic balance in the adult pelvis. *Extension* forces that tilt the pelvis upward are the muscles of the abdominal wall (anteriorly) and the gluteal and hamstring muscles (posteriorly) *Flexion* forces that tilt the pelvis downward or prevent excessive extension are the pubofemoral and iliopsoas muscles (anteriorly) and the sacrotuberous ligament (posteriorly) (Reproduced from Milch, H., Ischial apophysiolysis—A new syndrome, *Clin Orth* 2 189 1953)

the posterior part of the lever arm into a lever of the third class, in which the force is applied between the fulcrum and the resistance to be overcome. The combined anterior and posterior forces that tend to tilt the pelvis downward may be considered as concentrated just anterior to the apophyseal plate while the upward tilting force of the hamstrings is applied posterior to the plate At this point, a shearing strain is set up that can result in separation of the apophysis of the ischial tuberosity (Fig 51)

Although no actual measurements of the tensile strength of the apophyseal cartilage or its attachment to the bone are at present available, it must *a priori* be considered as sufficient to withstand normal stresses. It must, however act as a *locus minoris resistentiae* under the stress of the forces that are suddenly applied during the course of strenuous physical and sport activity This mechanism is precisely analogous to that which develops in so-called Osgood Schlatter s disease in calcaneal apophysiolysis, and in upper femoral epiphysiolysis, where the normally competent capital epiphysis is sheared

off by outward rotation of the excessively stressed femoral shaft acting against the resistance offered by the taut iliopsoas muscle.

Of all the muscles which, acting posteriorly tend to tilt the pelvis upward into extension, the hamstrings that are attached directly to the ischial tuberosity are the most important. This is of especial significance in understanding the pathomechanics of apophysiolysis. As has already been noted the attachment of the human biceps femoris muscle differs from the more generalized attachment found in lower forms in that the sacrotuberous tendinous portion of the human sacroperonealis complex acquires an additional point of insertion and is ultimately recognized as the sacrotuberous or great sacrosciatic ligament (Sutton[14]) The consequence of this is that the

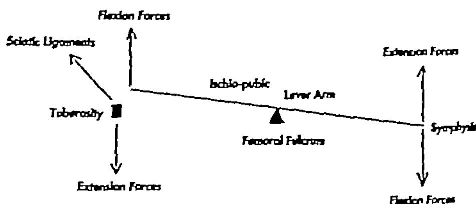


FIG. 51 Dynamic balance in adolescent apophysiolysis. The anterior and posterior flexion forces are greater than the extension forces and yield a resultant force that is transmitted to the region of the apophyseal plate. This establishes a shearing force couple concentrated at the apophyseal plate and leads to apophysiolysis. (Reproduced from Milch, H., Ischial apophysiolysis—a new syndrome. *Clin. Orth.* 2 189 1953)

tendinous portion of the human sacroperonealis complex acts precisely to oppose the downward motion that the muscular portion of this complex initiates. This serves to fix the apophysis and thus to localize and accentuate the counterbalancing action of the muscular forces that tend to elevate the ischium by tilting the pelvis downward (flexion)

Excessive displacement of the avulsed fragment presumably does not usually occur in consequence of the restraining action of the sacrotuberous or great sacrosciatic ligament. The fibers of this structure, directed upward and inward, are ideally arranged to counteract the forces of the muscles attached to the tuberosity of the ischium. The gemellus inferior the posterior fibers of the adductor magnus, and the quadratus femoris muscles tend to displace the fragment downward and outward while the hamstring muscles tend to pull the fragment directly downward. The resultant vector force, downward and outward, is diametrically opposed to the direction of the fibers of the sacrotuberous ligament, which courses upward and inward

(Fig 52) Excessive displacement of the avulsed apophysis is accordingly only possible in the event that the attachment of the sacrotuberous ligament either to the apophysis or to the sacrum itself has been disrupted

From the cases that have appeared in the literature, it is possible to reconstruct the clinical course of the condition and to correlate its symptomatology with the characteristic roentgen appearance. In the acute stage directly after injury the patient complains of severe pain, limp and limitation of motion. Sitting standing or any motion that tends to put the hamstring muscles under tension and thus pull on the avulsed fragment elicits exquisite pain An acutely tender mass may be felt or seen in the injured buttock and, on rectal examination, pain is sharply localized to the region

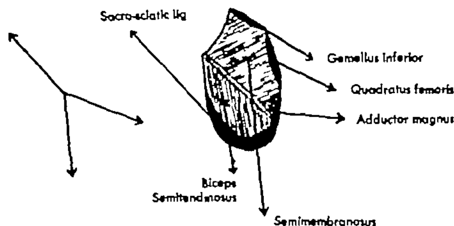


Fig. 52. Forces acting on the ischial tuberosity The direction of action of the different enumerated forces is indicated by the arrows. (Reproduced from Milch, H., Avulsion fracture of the ischial tuberosity *J Bone & Joint Surg 8* 832 1926)

of the ischial tuberosity The roentgenogram reveals an irregularity of the tuberosity as compared with the opposite unaffected side, or a characteristically crescentic-shaped shadow In patients in whom complete separation of the apophysis has not occurred, the roentgenogram may present the appearance of perischial calcification such as may be seen in tuberculous infection or tumors of the ischium The pathology is that of an acute fracture in many instances. Operative intervention will disclose the avulsed bell-shaped apophysis and the attached hamstring muscles lying in a fr— hematoma (Helmer[4])

HEALING

At a later stage evidence of early healing may be found. In a pr— operated upon by Karfiol[8] nine months after injury because of p— pain. The apophyseal fragment with its attached hamstring mu—

found to be movable but attached to the body of the ischium by dense fibrous connective tissue On removal, the fragment was found to be thickened by irregular masses of callus imbedded in a large mass of connective tissue. This is clearly representative of the healing stage that is visualized on the roentgenogram by the irregular thickening and apparent fragmentation of the lunate shadow (Fig 53)



Fig. 53 Ischial apophysiolysis. Fragmented shadow characteristic of the healing stage.

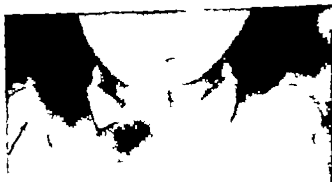


Fig. 54 Healed stage of ischial apophysiolysis. The prior existence of an apophysiolysis on the right side is indicated only by the fact that the tuberosity appears to be somewhat thicker than on the normal left side

In the event that healing proceeds uninterruptedly union of the apophyseal fragment with the tuberosity may be expected Even under extreme stress the symptoms will disappear and the site of the fracture will be recognizable on the roentgenogram only by the appearance of a thickened or irregular outline as compared with the opposite, unaffected side (Fig 54) If healing is interrupted, however the patient may continue to complain of disability owing either to pain or to the persistence of a mass in the buttock. In that event, as in the case reported by Winkler and Rapp,[14] twenty-five

years after the original injury the excised mass was described as "normal osseous matter with normal marrow elements, the exterior being partially lined by hyaline cartilage and tense tendinous tissue

Therapeutic indications are best determined by the correlation of the roentgenographic with the clinical course Since the condition is a fracture through the apophyseal plate as a result of muscular action, complete healing can be expected to occur provided the parts are put at relative rest This does not involve plaster immobilization, but merely avoidance of hamstring tension. Complete bed rest until bony union has occurred is ideal but does not appear to be imperative. Bed rest during the acute stage, and until all pain has disappeared is unquestionably necessary and will be readily acceded



Fig. 55 Ischial apophysiolysis. Left, avulsed apophysis before operation *right* after open operation and resuture. The apophysis has undergone aseptic necrosis. (Reproduced from Hellmer H., Case of traumatic separation of the epiphysis of the ischium. *Arch Orthop u Unfall-Chir* 34 45 1933)

to by the patient. Thereafter limited activity such as does not precipitate the reappearance of pain seems to have no deterrent effect on the normal process of healing

In general, a conservative approach to the treatment of this condition is indicated. If the separation is minimal, bony union may be confidently expected provided rest during the acute stage is enforced. Where the separation is excessive, fibrous rather than bony union will eventuate and recurrent episodes of pain may subsequently arise. In the acute phase, surgical intervention is contraindicated and skillful neglect is the treatment of choice. Plain neglect, however such as is manifested by failure to recognize the condition or permission to participate in strenuous activities, must be implicated as the cause of nonunion

The mere determination of nonunion does not in itself constitute an indication for treatment. Normal function is possible even in the presence

of nonunion. The patient described by Labuz[4] was not considered sufficiently disabled seven years after onset of symptoms to require any treatment other than physiotherapy Scott's patient seen four years after his original injury was completely asymptomatic. It must be admitted, however that nonunion does expose the patient to the possibility of recurrence of symptoms as a result of stretching or tearing of the surrounding muscles and the scar tissue in which the fractured fragment is imbedded. Where pain recurs or persists or where the detached fragment of bone mechanically interferes with normal activity surgical intervention would appear to be justified. The problem then is whether to attempt replacement of the fractured fragment or to excise the offending mass entirely

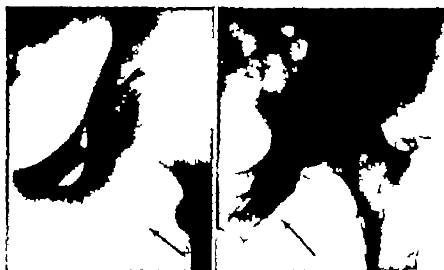


FIG. 56. Resection of avulsed ischial apophysis. *Left*, the appearance of the avulsed apophysis before operation; *right*, after resection of the avulsed apophysis. (*Courtesy of Dr H McLaughlin.*)

Through reposition and direct suture may appear to be the most ideal solution, it is clearly not the most expedient Surgical replacement is at all times difficult of technique and uncertain in outcome. In cases of established nonunion, the excess fibrous tissue encountered at operation so multiplies the difficulties as to render resuture unjustifiable. Hellmer performed open reduction with suture of the avulsed fragment. Though the result was reported to be satisfactory the roentgenogram (Fig 55) clearly indicates that aseptic necrosis occurred and that ultimate healing would require a long period of creeping substitution. In a similar situation, Darrach is reported to have met failure after attempted resuture.

Where symptoms persist beyond the time when healing may be expected to take place, excision of the mass with reattachment of the hamstring muscles offers probably the best hope for speedy symptomatic relief Berry

Karfiol, and Winkler and Rapp[15] excised the nonunited apophysis without any apparent residual disability to the patient (Fig 56*A B*) and this is undoubtedly to be preferred to misguided efforts at resuture.

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CHAPTER 8

Periosteitis of the Ischium, Gracilis Exostosis, Osteitis of the Ischium

PERIOSTEITIS

PERIOSTEAL REACTIONS ALONG the inferior aspect of the tuberosity of the ischium may be seen in a variety of different conditions. They are common during the development of pyogenic or tuberculous osteomyelitis, may occur during the course of infections elsewhere in the pelvis (Fig 57) and are invariably a stage in the life history of ischial decubitus ulcers. They may appear however in conditions in which no question of infection can arise.

Periosteal changes without any lytic lesion in the body of the ischium have been described by Krebs.[6] This observer who in 1934 first called attention to the arthritic manifestations in the sacroiliac joint as probably the earliest sign of ankylosing spondylitis, noted that a "vesicular periostitis of the ischial tuberosity was a common roentgenographic finding in this condition He observed that, though not always present, it was a more common early finding than the typical changes in the apophyseal joints of the spine. He considered these changes to be of an inflammatory nature and probably due to invasion of the periosteum by vascular connective tissue found in rheumatoid conditions. In mild cases, a relatively benign periostitis was present, but in the more severe cases extensive erosion of the body of the ischium had been observed.

Iller[4] who corroborated this opinion, was led to a study of the condition



Fig. 57 Bilateral periostitis of the ischial tuberosities following septic abortion. (Courtesy of the National Institutes of Health.)

by the observation of a patient with ankylosing spondylitis. This patient complained of pain in the right groin and thigh. X ray examination disclosed an irregular periostitis of the tuberosity with ankylosis of the symphysis (Fig 58) In seventeen other cases that Iller collected, she noted ankylosis of the symphysis in nine cases and varying degrees of periostitis of the ischial tuberosity in nine cases. She observed that erosions of the tuberosity might be extensive and might simulate the findings in definite ischial tuberculosis, and particularly called attention to the differentiation between this condition and the so-called gracilis exostosis noted by von Baeyer as characteristic of arthritis deformans.



Fig. 58 Periostitis of the ischium. Irregular periosteal proliferations with beginning ankylosis of the symphysis pubis in a patient with ankylosing spondylitis. (Reproduced from Iller M Changes in the symphysis and the ischium in Bechterew's disease *Röntgenpraxis 11* 542, 1939)

GRACILIS EXOSTOSIS

In certain patients, the periosteal changes that have been described as occurring in the region of the ischial tuberosity seem to be concentrated near the origin of the gracilis muscle and have therefore been called "gracilis exostosis." Von Baeyer who had noticed this along with other changes in the diaphysis of the long bones, believed its appearance was pathognomonic of arthritis deformans of the hip Schiff undertook a study of the condition at the suggestion of von Baeyer and found it present only in those patients with arthritis deformans of the hip in whom there was an associated dorsal kyphosis, flat pelvis, and flat foot with everted gait. To explain this peculiar concatenation of signs, Schiff elaborated an ingenious theory based on the

assumption that the dorsal kyphosis necessarily enforced a compensatory lumbar lordosis. Since the degree of compensation possible in the lumbar spine was less than the degree of kyphosis possible in the dorsal spine, the deficit necessary to re-establish stable equilibrium was compensated by upward tilting of the pelvis. This displaced the center of gravity backward over the lower extremities but at the expense of excessive strain on the Y shaped ligament of Bigelow and the muscles, especially the gracilis, attached to the anterior lever arm of the pelvis. As a consequence, and in accord with Wolf's law of bone transformation, the exostosis developed at the site of excessive gracilis strain.

Without in any manner denying the possible validity of gracilis strain in the development of the exostosis, its pathognomonic significance in



FIG. 59 Bilateral gracilis exostosis in a female with osteoarthritis of the right hip. There are no signs of kyphosis and no flattening of the pelvis.

arthritis deformans may be seriously doubted. Even Schiff admitted that it was not found in all cases of arthritis deformans, but only in those associated with dorsal kyphosis, flat pelvis, and flat everted feet. This seemed to bespeak a particularly determining role to elements other than the arthritis deformans. Strangely enough, it was not constantly found even in those patients with kyphotic spines, flat pelves, or flat everted feet in whom, but for the arthritis, the associated conditions postulated for the appearance of the gracilis exostosis were present.

From the evidence adduced by Schiff it appeared that neither the arthritis itself nor the kyphosis offered sufficient explanation for the genesis of the gracilis exostosis. This became more obvious when the pelvic roentgenograms of patients under treatment for other conditions were examined with special reference to the presence of the exostosis. It was soon found that (1) patients with arthritis of the hip but without dorsal kyphosis (Fig 59) (2) patients without arthritis but with kyphosis (Fig 60) and (3)



FIG. 60 Periostitis of the ischium on the right side and gracilis exostosis on the left side in a female with marked dorsal kyphosis resulting from tuberculosis of the spine There is no arthritis and the pelvis is flat.



FIG. 61 Bilateral gracilis exostosis in a male with Paget's disease There is no arthritis, no kyphosis, and no flattening of the pelvis.

patients without either arthritis or kyphosis (Fig 61) might present x ray evidence of the gracilis exostosis. While the exostosis undoubtedly developed in response to some forces, presumably strain at the insertion of the gracilis muscle, the conclusion that it could be looked upon as a pathognomonic sign of arthritis deformans appeared to be entirely unsupported

ISCHIAL OSTEITIS

Under the title, "Some Cases of Destruction of the Ischium of Doubtful Etiology," Odelberg[1] described four cases that he believed represented a "non-specific inflammation of the ischium. Two boys aged eleven, one aged fifteen, and a girl aged thirteen presented the same clinical and roentgenographic picture (Fig 62) Without any antecedent history of injury these children began to complain of pain along the inner aspect of the thigh with

radiation to the knee. Prolonged walking or any movements that put a strain on the affected limb resulted in a painful limp. In the early phases of the condition, this was accompanied by a low-grade fever.

Clinical examination revealed no atrophy of the thigh or gluteal musculature, but all showed signs suggestive of hip joint disease. In all, the x-ray disclosed evidence of a rarefying osteitis with decalcification and even widespread destruction suggestive of tuberculosis of the ischial tuberosity. The serology and tuberculin tests were negative. All were operated upon.



Fig. 62 Destruction of the ischium. The area of radiolucency is similar to that seen in tuberculosis. (Reproduced from Odelberg A., Some cases of destruction in the ischium of doubtful etiology. *Acta chir scandinav* 56.273 1942.)

In the first case, microscopic examination revealed "a fairly cellular tissue with considerable cell division and markedly infiltrated with plasma and round cells. Here and there polymorphonuclear leucocytes. Inflammatory changes of a non-specific nature. Case 2 showed "profuse infiltration of pus cells." Case 3 disclosed "a vascular tissue rich in cells made up principally of round cells, part of which were polymorphonuclear leucocytes or cells akin to these. Here and there typical plasma cells. In addition, there were even more oval cells closely packed together and among them mitoses taking place freely. No tubercles or giant cells."

No bacteriological growth could be obtained from the pus or the tissue either on culture media or by guinea pig inoculation in any of the cases. In the first three cases, the foci were completely exenterated with prompt subsidence of symptoms. In the fourth case, the exenteration was incomplete and symptoms continued for a number of years.

The absence of more precise data precludes the possibility of either establishing or excluding any definite etiological agent. From the location of the lesion and the age of onset, the likelihood of ischiopubic osteochondritis of the type described by Van Neck[9] would seem to be slight. Wülfing[11] was inclined to consider the lesion in the nature of an apophysitis. This possibility cannot be dismissed entirely because the ischial apophysis develops exactly within the age period during which the condition was noted. On the other hand, the extent of the involvement and its primary localization somewhat anterior to the actual site of the apophysis casts some doubt upon this explanation.

In 1936 Fitte[2] described two cases occurring in children about the age of eleven, which except for the absence of fever appear clinically and roentgenographically to be identical with those described by Odelberg As in those cases, both the serology and the tuberculin tests were negative. Unfortunately the histology in these cases could not be determined because under conservative therapy the condition resolved with complete bony regeneration Fitte especially emphasized his belief that the condition he described was similar to that described by Voltancoli[10] except for the fact that the lesion was located in the tuberosity and not in the ischiopubic junction.

The conditions described above seem to be similar clinically and roentgenographically with ischial osteitis occurring at a later age. In 1952 Golden[3] reported the case of a twenty-six year-old woman who two weeks after an abortion, developed pain in the perineum and right lower extremity The pain in the perineum, especially on flexion of the thigh, persisted and roentgenogram revealed an osteitis of the ischium that subsided under conservative therapy Golden was of the opinion that the condition might arise either from inflammatory or neurotrophic causes and was similar to if not identical with, the pubic osteitis described by Beer[1] after operations in which the urinary bladder had been opened.



FIG. 63 Osteitis of the ischium. Roentgen evidence of ischial destruction developed four weeks after prostatectomy and subsided under symptomatic treatment. (Reproduced from Klinger M E, and Levine, J *Ischial osteitis New York J Med 53* 1579 1953)

The same opinion was expressed by Klinger and Levine[4] who reported the case of a fifty five year-old man in whom a one-stage prostatectomy had been performed four weeks before the onset of left sciatic pain. Examination disclosed tenderness over the tuberosity of the ischium and x ray showed "an area of rarefaction in the left ischium below the acetabulum" (Fig 63) Under rest, analgesia, and physiotherapy the symptoms subsided. There was gradual resumption of normal locomotion. A follow up x ray study of the pelvic bones after a month had elapsed showed osseous regeneration in the affected area of the ischium. No subsequent symptomatic or objective sequelae resulted

Without specifically mentioning the possible role of the vertebral system of veins, the authors shrewdly suggested as an explanation some relation

ship to the long standing infection in the prostate. It may be that a smouldering thrombophlebitis involving a group of small venous radicals in the pelvis was present. In communicating with veins draining the pelvic bones, an extension of the process to them was permitted and finally caused an occlusion of these venous channels resulting in the local changes noted in the bone

OSTEITIS DEFORMANS

Paget's disease, osteitis deformans or osteitis hyperplastica, is a disease characterized by enlargement and deformation of bones (Fig 64) Its onset



Fig. 64 Paget's disease of the pelvis. Longitudinal striations and cyst like areas are seen throughout the pelvic bones.

is usually after the fortieth year and it most commonly involves the skull, the vertebrae, the sacrum, the pelvis, the femora, and the tibiae. Its etiology is unknown and Paget's original theory of inflammatory origin has been discarded. The disease is insidious in onset and is frequently discovered accidentally during the course of examination for other suspected conditions.

Patients often complain of pain long before the diagnosis is established. Curving of the long bones of the leg or difficulty in fitting a hat to the increasing size of the head is frequently the first symptom that the patient notices. Involvement of the vertebral column leads to pain in the back and a gradual loss of height so that, with the curved femora and tibiae, the arms appear relatively too long and the patient assumes an attitude that has been described as simian.

Usually the disease is polyostotic but it may appear in monostotic form that may occasionally come on after trauma. In its fully developed form the diagnosis is most readily made on the basis of the roentgenographic appearance of the involved bones. The pelvis may present the typical "cotton wool" appearance or there may be coarse fibrillar striations with areas of cystlike resorption Isolated involvement of the ischium is rare.

Histologically Paget bone presents evidence of increased bone destruction and reformation. As a consequence of these rapid changes the normal regular appearance of the bone is disturbed and on section presents an irregular mosaic pattern. The bone trabeculae are coarse and thick In areas of activity they are lined both with multinucleated osteoclastic giant cells and osteoblasts. The bone marrow is of a fibrous nature. In resting areas these cells are absent and the bone marrow is usually fatty The bone reconstruction appears to progress at a more rapid pace than the destruction and as a result, the diameter of the bone increases. The bone formation, however occurs so rapidly that complete calcification does not take place and a large part of the newly formed bone remains in an osteoid state. The consequence of this is that though the bones are thicker their calcium content is lower than in normal bones.

Despite the apparent disruption of the normal vascular pattern in Paget s bone, there is a marked increase in blood flow that is estimated to be as much as twenty times that seen in normal bones. This has been explained as being due to the formation of numerous small arteriovenous shunts similar in their effect to that seen in arteriovenous aneurysms. This accounts for the "hyperemia" seen in Paget s bone, the increased skin temperature over areas of Paget s bone, as well as for the signs and symptoms of cardiovascular disturbance often found in cases of advanced Paget s disease

While the serum calcium and inorganic phosphorus are within normal limits, the serum phosphatase is notably increased in active Paget s disease. Where the disease is not active, or in the beginning of a monostotic involvement, the phosphatase may not be elevated. Its determination is not of pathognomonic significance and is merely indicative of osteoblastic activity

Pathologic fractures are not uncommon in Paget s disease Often it is the appearance of such fractures after relatively slight trauma that leads to the accidental discovery of the existence of the disease. These fractures occur mainly in the long bones and are unusual in that they are transverse in their trajectory Healing occurs in these cases without any difficulty and often with excess callus.

Sarcomatous transformation has been noted in a considerable number of these cases. Most frequently these sarcomata are of the osteogenic variety but chondrosarcomas and fibrosarcomas have also been reported. It is sometimes very difficult to determine the existence of a malignant degeneration



FIG. 65 Isolated Paget's disease of the ischium. Longitudinal striations with cystlike areas localized only to the ischium.

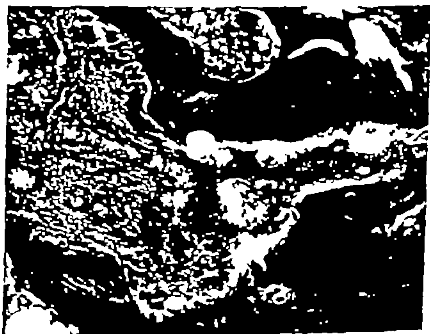


FIG. 66. Isolated Paget's disease of the ischium. Microscopic section of tissue removed from the patient of Figure 65 The bony trabeculae are thickened and irregular and present the typical mosaic appearance of Paget's disease. The marrow is fibrous.

or to be certain of the absence of malignancy particularly in monostotic forms of Paget s disease This is illustrated in the following case

E. S., female, aged forty four gave a history of some gynecological operation fourteen years before the onset of pain following an injury to the hip. X ray of the hip (Fig 65) was reported as showing "coarse striations involving the acetabulum and the ischium Diagnosis advanced Paget s disease." Despite this, the history of loss of sixteen pounds during the previous six months without any effort at dieting and the history of an earlier gynecologic operation suggested the possibility of malignant involvement of the ischium

Biopsy was performed. The microscopic report "pronounced bone destruction with moderate bone production" completely sustained the radiologist s opinion of Paget s disease (Fig 66)

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CHAPTER 9

Pyogenic Osteomyelitis of the Ischium

INFECTION OF THE ISCHIUM may occur as the result of many different organisms. Infections by actinomyces,[11] echinococcus,[17] Fraenkel's diplococcus, Ebert's bacillus, Pfeiffer's bacillus, pyocyaneus, as well as by the more commonly known organisms such as staphylococcus, streptococcus, and the tubercle bacillus have been reported.

Though a number of cases of pyogenic osteomyelitis have been reported, the incidence of isolated pyogenic infection of the ischium must be considered as low. In 1 949 cases of osteomyelitis collected from the literature, Klemm[7] found involvement of the pelvic bones in only 35 cases, with ischial involvement in none. In 385 instances of osteomyelitis seen in 320 of his own patients, 36 involved the pelvis and only 2 the ischium (0.005 per cent). A somewhat similar incidence was reported by Oreto[12] who in 100 cases of osteomyelitis, observed at the surgical clinic of Messina, found 11 involving the pelvis and only 2 involving the ischium (0.0125 per cent). Of these, 1 was isolated in the ischium and 1 in the ischium and the femur.

On the other hand, in 71 cases of childhood osteomyelitis, Doran and Brown[3] found 3 in the ischium (0.04 per cent). This incidence is eight times greater than that reported by Klemm and more than three times greater than that reported by Oreto. This would seem to indicate that the incidence of ischial osteomyelitis is greater in children than in adults. This may be explained by the presence of epiphyseal cartilage plates with metaphyseal end arteries both at the ischiopubic junction and at the tuberosity.

Localization of the infection to the region of the ischiopubic junction appears to be more common than to the tuberosity. Such cases have been de-

scribed by Bilhaut,[1] Inglerans,[8] Le Fort,[9] Ottolenghi,[11] McWhorter,[10] Colvin,[3] Söderlund,[14] Zaffagnini,[19] Valks,[18] Ligas,[9] and others. Cases in which the infection originated in or was localized to the tuberosity have been reported by Pokorny,[14] Geist,[4] and others.

The following case is interesting both with respect to its pathogenesis and bacteriology.

M. R., male, age sixty five, was admitted to another hospital with a diagnosis of hypertrophied prostate. Suprapubic drainage was instituted but shortly thereafter the patient began to run a septic temperature up to 104° Fahrenheit, and complained of pain in the right hip and perineal region. One month later a perineal



FIG. 67. Subacute osteomyelitis of the ischial tuberosity. There is a periosteal reaction with a crescentic shadow somewhat suggestive of that seen in ischial apophysiolysis. There is, however, in addition, evidence of destruction of bone in the ramus and in the inferior aspect of the tuberosity.

incision was made exposing the prostate but no pus could be located. The patient left this hospital with a suprapubic tube in place. When first seen, he was still complaining of pain in the ischial region and x rays disclosed evidence of irregular destruction in the region of the right ischial tuberosity, similar to that seen in younger adults with ischial apophysiolysis. The left ischial tuberosity revealed only a slight periosteal proliferation (Fig. 67). Incisions were made over both ischial tuberosities. On the left side, no pus was found even after elevating the periosteum. On the right side, a small amount of pus was found in an abscess cavity around the ischial tuberosity which extended toward the pubis along the pubic ramus. Culture of this "pus" revealed staphylococcus and bacillus pyocyaneus. The wound drained for 4 to 5 days and then closed (Fig. 68).

The infection may be blood-borne and may be primary in the ischium or it may be secondary to infection in the hip joint or the femur. In one of the cases reported by McWhorter the infection followed a "cold" and in others

was secondary to infection of the femur. In Pouzet's[11] case, the infection followed a fall and in the case reported by Le Fort came on after a blow on the thigh of the affected side.

The onset may be gradual and in several cases reported by Geist the development of fistulous openings gave the first indication of the underlying condition. Usually, however, the onset is sudden with a high fever and other signs of sepsis. The patient complains of pain about the hip or in the perineum and there is limitation of motion in the hip that may suggest hip joint involvement. In contrast to true hip joint infections, not all the motions of the hip are concentrically limited. This is a diagnostic point of great im-



FIG. 68. Subacute osteomyelitis of the ischial tuberosity. Following drainage of the ischial abscess, there is a slight irregularity of the bone at the site of surgical intervention.

portance and selective limitation of some of the hip motions indicates the need for further investigation of the case. Probably the most valuable evidence may be obtained by rectal examination. The presence of localized tenderness or swelling along the ramus or the tuberosity is of the utmost significance. This is well illustrated in the following case.

A three-year-old child was taken with chills and high fever several days after a "cold." The right thigh was held in abduction and external rotation, and the child was admitted to the Hospital with a tentative diagnosis of epiphysitis of the hip. Though the child resisted any attempt at internal rotation and adduction, the thigh could be passively flexed and extended slightly without undue pain. Rectal examination revealed point tenderness along the ischial ramus with a boggy swelling at the lower margin of the obturator foramen. With the rectal finger as a guide, this mass was aspirated through a long needle inserted across the ischiorectal fossa. A few drops of pus from which staphylococcus was grown were recovered. A small incision in the perineum permitted evacuation of the abscess

with prompt subsidence of all symptoms. The x ray disclosed no evidence of bone destruction, and the wound closed within a short time without any residual disability

In the preantibiotic period McWhorter reported a mortality of 10 per cent in these cases. Unless promptly drained, the subperiosteal abscess may perforate into the hip joint and lead to a septic arthritis, as has been reported by McWhorter Pouzet, Le Fort Guilleminet [8] and others.

In the case of the six year-old boy described by Ottolenghi the abscess spread along the ischiopubic ramus and probably by pressure on the cavernosus muscle, led to a distressing priapism that subsided only after incision and drainage. Fistulization of the periosseous abscess into the ischiorectal fossa has occurred leading to a mistaken diagnosis of a primary ischiorectal abscess with persistent drainage, until the bone focus was recognized and treated. Where the abscess points in the perineum, its presence is quickly betrayed by swelling If the pus spreads along the plane of the pelvifemoral muscles, it may lead to secondary infection of the posterior or medial fascial compartments of the thigh and necessitate extensive drainage of the thigh before the infection can be controlled

As in other infectious processes, the widespread use of antibiotics has resulted in a profound change in the clinical picture these cases present. The septic symptoms are quickly brought under control and what would earlier have been immediately recognized as an infection not infrequently raises the suspicion of a malignant process. The same is true of those cases in which the onset is not as explosive as in the acute cases. This is seen in the following case treated by Dr S Kleinberg

J S., a male, aged fifty-two began to complain of a "pinching" pain and a "burning" sensation in the right buttock, radiating to the right thigh and right knee. The pain was not constant and appeared to be improving X ray made several weeks previously had been reported as showing a neoplasm but biopsy was reported to be negative.

The patient, nevertheless, was not satisfied and came for further study The Mazzini and Bence-Jones tests were negative. The urine, blood count, and blood chemistry were within normal limits. X ray was reported as showing a "patchy osteitis of the right ischium. Areas of resorption are present in the lower third of the body of the pubic bone. At the junction of the descending ramus of the pubis and the ascending ramus of the ischium there is indication of a partly united fracture (biopsy) There is no cortical thickening no periostitis and no regional mass. The original films were inspected. They show what appears to be an osteolytic lesion in the body and descending ramus of the right ischium with a pathologic fracture. While an atypical tumor must be considered the radiographic findings at the present time suggest a fracture at the level described followed by a traumatic osteoporosis. The pre-existing areas of resorption notable in the pubic bone appear to be healing" (Fig 69)

Biopsy was performed through a small perineal incision. The pathologist re

ported "thickening of the osseous trabeculae. Extensive scarring of the intertrabecular marrow and evidence of chronic inflammation as indicated by the presence of numerous lymphocytes and other inflammatory cells. Diagnosis: low grade chronic osteomyelitis of the ischium. No indication of tumor formation.

While it may be hoped that the use of antibiotics has eliminated the earlier type of fulminating septic infections, the probability of a low grade of chronic osteomyelitis of the ischium must always be kept in mind in cases that present atypical symptoms of hip joint infection, or even infection of the ischiorectal fossa. Any doubtful lesion in the ischium can be easily investigated through a relatively small incision over the subcutaneous portion of the ischium in the perineum.



FIG. 69 Chronic osteomyelitis of the ischium. The persistence of irregular areas of ossification in the tuberosity and ramus raised the suspicion of neoplastic involvement. (Courtesy of Dr S Kleinberg)

Treatment of acute osteomyelitis of the ischium is by incision and drainage. The wound should be packed open until healing has occurred from the depths of the wound. No immobilization is necessary. In chronic cases, resection of the involved portion of the bone is to be preferred to simple saucerization of the affected area. Adequate doses of appropriate antibiotics are of value in the treatment of acute cases, but, in instances of chronic osteomyelitic infection, resection under the coverage of antibiotic therapy is the treatment of choice.

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CHAPTER 10

Tuberculous Osteomyelitis of the Ischium

THE ISCHIUM is one of the more unusual sites of localization of osseous tuberculous infection. Magnusson[13] noted that of all the cases of bone tuberculosis seen between the years of 1928 and 1936 only 0.2 per cent involved the ischium. Similarly, in a series of 5,384 cases of skeletal tuberculosis, Rebaudi[15] found 100 involving the pelvis and 16 involving the ischium. Prior to 1910, reference to tuberculosis of the ischium is very scant in the literature. Gant[6] reported a single case, Zellmeyer[23] collected six cases from the literature, Blankoff and Powell[18] each reported another case, and Mazzari[14] reported three cases, in which the clinical diagnosis was made but in which tuberculosis was not proved. Isolated reports were made by Voltancoli,[22] Mazzoni,[14] Guyot,[7] and others. After 1930, however, the condition appears to have been diagnosed more often and a number of reports of individual cases have been made by Serrati,[3] Grunert,[6] Tupman,[21] Clavel,[3] Kaplan,[8] and Milch.[14,17] Inglerans and his co-workers[8] described six cases and, in discussing their report, Sorrel and Sorrel-Dejerine[23] reported 14 cases, 7 in adults and 7 in children. Trivelli[24] in a study of 579 cases of skeletal tuberculosis found 100 involving the pelvis with 12 in the ischium, an incidence almost ten times as great as that reported either by Rebaudi or Magnusson.

Tuberculosis is less frequently encountered in the ischium than in any of the other pelvic bones, with the exception of the sacrum. Zellmeyer, Reifland,[20] Ludloff[11] and others have called attention to the fact that tuberculosis of the ischium is unlike tuberculosis of the long bones and the disease commonly resembles that seen in tuberculous epiphyseal and apophyseal infections.

Terrillon is quoted by Zellmeyer to the effect that tuberculosis occurs by preference near epiphyseal lines and that therefore, at the outset tuberculosis of the pelvis appears as an "osteitis of the inner aspect of the pubis, the ischial tuberosity the iliac crest the ischial spine and the posterior superior spine of the ilium." With the exception of Terrillon, isolated tuberculosis of the spine is not mentioned by any other author and it may be accepted that the tuberosity is typically the area in which ischial tuberculosis is localized. Indeed, the fact that the apophysis of the ischial tuberosity does not develop until after the age of eleven has been suggested as the explanation of the fact that the majority of cases have been diagnosed in young adults. This may not be a valid argument, however since the time of recognition may not represent the age of onset of the infection This is indicated by Sorrel's reports of tuberculosis in children and more specifically by the report of Serrati who described an infantile type of ischial tuberculosis. Moreover this does not account for the fact that tuberculosis of the ischiopubic junction is seldom found as the site of origin of tuberculosis of the ischium.

The infection is blood-borne and localizes primarily in the spongiosa. In its early stages, tuberculosis of the ischium presents the appearance of gray-red granulation tissue in which, microscopically multinucleated giant cells and thickened bone trabeculae are found At this time the x ray usually gives little clue to the existence of any pathological process. Later when extensive destruction has occurred, the x ray discloses the presence of the osteolytic lesion in which sequestrae may be seen. The extent of involvement, however is never revealed by roentgen appearance and typical tuberculosis with tubercle bacilli can be demonstrated throughout the bone in the presence of an apparently normal roentgenogram. In fact, the development of fistulae may be the first indication of the presence of a tuberculous infection Caries sicca is rare, and abscess formation is most common.

The onset is insidious with but little elevation of temperature. Its evolution is slow Pain is minimal until the tuberculous abscess in the bone approaches the surface when it may become severe and resemble sciatica or a hip joint infection. At this time, the ischium may be tender and is usually enlarged Fistulae may appear in the gluteal region or in the perineum. In one case reported by Lorthoir [11] a urethral fistula, which was mistaken for a urinary tract abscess, could not be brought to healing until thorough curettage of the ischium had been accomplished These fistulae spread along the muscle planes and especially those that open in the buttock are often mistaken for simple ischiorectal infections.

Next to actual demonstration of the organism by aspiration the roentgenogram is the most valuable and frequently the only available diagnostic medium. X ray evidence does not appear until a variable time after the infection has been established Depending on the severity and extent of the in

volvement, the roentgenogram may disclose a small area of destruction on the posterior or inferior border of the tuberosity (Fig 70) In more advanced cases, it may present a crescentic shadow very suggestive of that seen in ischial apophysiolysis. It is, however to be differentiated from this latter condition by the fact that there is irregularity and osteoporosis on both sides of the epiphyseal plate instead of a smooth separation. At a later stage, more or less extensive destruction of the tuberosity with the formation of sequestrae is characteristic of the condition Trivelli noted that sequestrum formation occurred in 90 per cent of the cases of apophyseal tuberculosis

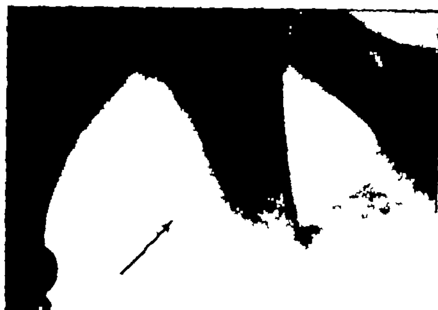


Fig. 0 Early tuberculosis of the ischium. There is a small area of destruction on the posterior aspect of the tuberosity Tubercle bacilli were recovered on aspiration of this area.

and could almost be considered as pathognomonic of the condition. Becker[3] attributed this to the regenerative capacity of the tissue in the vicinity of the epiphyseal plate. It may well be that this is also the explanation of the cystic appearance of the juxta apophyseal tissue to which Kienböck called attention.

Second only in importance to the demonstration of characteristic x ray lesions, is the appearance of fistulous discharge from quiescent abscesses. Tuberculous ischial abscesses may remain relatively symptom free for long periods of time and their earliest manifestation may be a fistulous discharge following a posttraumatic or spontaneous rupture of the enveloping bony wall It has been stated that a tuberculous abscess located in the posterior aspect of the ischium tends to track downward and discharge beneath the free border of the gluteus maximus. Abscess of the ascending ramus may dis-

charge higher through the sciatic foramen, while abscess of the descending ramus forming between the bone and the obturator internus may either track along that muscle and open on the outer side of the femur or may as in Lorthoir's case, track along the ischiocavernosus muscle and drain into the urethra. Abscesses forming between the bone and the obturator externus may drain through the perineal region, the inner aspect of the thigh or as in Fevrier's case[4] into the space of Retzius. In Gant's case, there was an associated ischiorectal abscess and, in the case reported by Rose,[20] two fistulous openings, one in the ischiorectal space and another in the perineal region were described

Despite the diversity of pathways by which discharge from a periischial abscess has been described, rupture into the hip joint seems to be unknown. Indeed, it appears to be the rule that while a septic arthritis of the hip secondary to pyogenic osteomyelitis is common, infection of the hip secondary to tuberculous infection of the ischium does not occur This is more remarkable in that sections of the ischium removed for tuberculosis have been shown to harbor tubercles in areas close to acetabulum where there was absolutely no roentgenographic evidence of bone involvement. On the other hand, intrapelvic perforation of a periischial tuberculous abscess is not unusual.

All observers are agreed that bone tuberculosis is merely a local manifestation of a disseminated disease and that treatment of the condition involves two separate considerations (1) care of the patient's health in general and (2) care of the local lesion. In the prechemotherapeutic era reliance for improving the general condition of the patient was placed on bed rest diet, and heliotherapy Since the development of chemotherapeutic agents, however the necessity or value of these ancillary measures has been seriously questioned. Indeed, Selikoff[21] and Selikoff and Rabin[22] have expressed the opinion that "further experience will confirm that bed rest, except for acute disease or in the presence of constitutional symptoms, adds little to chemotherapy Should chemotherapy not be available, however because of toxicity bacterial drug resistance, etc., bed rest might be utilized advantageously"

First progress in the modern chemotherapy of tuberculosis came with the development of streptomycin, but it was later found that streptomycin in combination with other antituberculosis drugs, such as para-aminosalicylic acid and, more recently isoniazid or iproniazid, gave better results than either drug when given individually

Optimal effects appear to derive from the simultaneous use of three antituberculosis agents, dihydrostreptomycin, para-aminosalicylic acid, and isoniazid, given for a minimum period of at least one year Iproniazid appears to be more desirable than isoniazid when there are systemic effects, but

should be discontinued as soon as constitutional symptoms have disappeared. This regimen by itself appears to be of value only in synovial tuberculosis or minimally involved bone tuberculosis. Where there are definite areas of caseous necrosis and abscess formation, chemotherapy alone is insufficient and must be combined with operative surgical intervention.

Surgery must be such as to exenterate the necrotic focus, but can be performed more safely under the cover afforded by a chemotherapeutic regimen. Despite surgery chemotherapy should be continued for a period of at least three months and preferably for a period of about one to one and a half years. Barring the development of allergies or drug sensitivity chemotherapy should consist of para aminosalicylic acid, 10 to 15 Gm. daily by mouth, dihydrostreptomycin, 1 Gm daily intramuscularly, and isoniazid, 4 mg per kg of body weight, daily

In tuberculosis of the ischium, the most expeditious method of removing the focus of the infection, and thus avoiding the possibility of complications, is by resection of the entire ischium. Saucerization of the local area alone is inadequate and examination of tissues removed at operation has repeatedly demonstrated the existence of histological tubercles in apparently nonaffected areas far removed from the area of destruction grossly demonstrated by roentgenographic examination. The inadequacy of less extensive intervention is seen in the following case which is reported through the courtesy of Dr. L. Mayer

This patient, O F., was originally admitted to the hospital in 1933 at the age of six, for the release of a shoulder contracture resulting from Erb's palsy In 1936, he was readmitted for incision and drainage of an abscess resulting from tuberculous cervical adenitis. In May 1939 he was readmitted because of pain in the right hip region that radiated to the knee. Flexion of the hip was possible only to eighty degrees and the thigh was held in slight external rotation. There was some tenderness on palpation of the right ischial tuberosity and the temperature rose to 102 Fahrenheit. X ray disclosed some irregularity in the contour of the ischial tuberosity with a poorly developed symphysis pubis. Though the possibility of tuberculosis was entertained, it was felt that conservative treatment was indicated and the patient was sent to the country home. While at the country home a sinus appeared over the outer end of the right clavicle and three sinuses developed in the right buttock. There was a flexion contracture of the hip at one hundred fifty degrees and flexion was possible to only ninety degrees. X ray at this time showed sequestration of the posterior portion of the ischial tuberosity (Fig 71) The tuberosity was resected in January 1940 (Fig 72) The patient's postoperative course was stormy and he continued to run temperatures. This was attributed to the tuberculous infection of the clavicle that was resected. This did not give more than temporary relief In February an abscess developed in the perineum at the base of the scrotum. This was incised and drained. In March, an infection of the posterior fascial space of the thigh developed that necessitated incision and drainage. The patient subsequently developed evidence of amyloid disease of the liver and the Congo red test was strongly positive. He ultimately developed signs of peritoneal involvement and died. It is questionable

whether earlier surgery would have saved this child's life but there is no doubt that resection of the ischium at the time of the first diagnosis would have spared the child the additional distress of abscess formation, with multiple incisions and drainage.

On the other hand, the beneficent effect of wide and early resection of the ischium is shown in the following cases.

I F., male, aged twenty-eight was first seen in February 1940 with a history of swelling of the right thigh that developed fourteen months previously following exercise on a mechanical horse. Four months before admission to the hospital,



FIG. 71 Case O F The posterior portion of the ischium has sequestrated and is separated from the body of the bone. There is evidence of involvement of the subacetabular bone but without invasion of the hip joint. The roentgenogram is somewhat suggestive of the appearance seen in ischial apophysiolysis.

a mass was noticed below the right gluteal fold and four weeks before admission this mass became painful. Under hot bath treatment a fistulous opening appeared. A small incision was made with the evacuation of much grumous material and the wound was packed. The patient later ran a temperature up to 102 Fahrenheit and was admitted to the hospital where adequate incision and drainage was instituted. Culture of the pus obtained was sterile, but guinea pig inoculation was subsequently reported to be positive for tuberculosis. X ray studies made several days after the incision were reported as showing "irregular necrosis of the ischial tuberosity as well as the ascending ramus of bone. Several abscesses are present within the bone. Diagnosis tuberculous osteomyelitis of the ischium."

Three weeks later subperiosteal resection of the ischium from the level of the ischial spine to the body of the pubis was performed. The wound, however did not heal and several months later the patient developed a large abscess of the right thigh that required incision and drainage. The wound in the perineum still remained unhealed and, in June, 1942, the patient was readmitted with a right ischiorectal fossa abscess. The abscess was incised and drained. No tuber

culous was found in the wall of the cavity Thereafter all wounds healed and the patient has remained symptom-free since.

The following case is presented through the courtesy of Dr J Buchman

R. R., male, age twenty-one, was admitted to the hospital in October 1944 with a history of a fall injuring the right hip three years previously Thereafter the patient had difficulty in running and had slight limitation of motion in the right hip. Two years before admission, the patient was seen by another physician who had x rays made. These were reported as showing an area of bone destruction of the body and ramus of the ischium with spicules of bone in the soft tissue



FIG. 7 Case O F After operation. The ramus of the ischium and all the tuberosity have been resected.

and periosteal elevation along the lower border of the neck of the femur suggesting a low grade osteomyelitis." Nothing was done at this time.

In April, 1944 an abscess developed on the lateral aspect of the right femur This was opened with the evacuation of a large amount of pus. By September the sinus seemed dry but did not heal The patient suddenly ran a temperature up to 103 Fahrenheit, but this subsided as soon as the abscess in the thigh again opened

On his admission to the hospital, the patient walked with a right hip limp, and had limitation of hip flexion at ninety degrees. The skin over the right ischial tuberosity was red with increase in local temperature. The area of the ischium was indurated and fluctuant. X ray disclosed "an irregular area of necrosis involving the cortex and a portion of the marrow cavity of the tuberosity of the right ischium. Adjacent to this area there are irregular calcific deposits probably tuberculous in character In the soft tissues over the posterior and inner aspects of the right femur at the junction of the middle and upper thirds of the shaft, there are small calcific deposits distinct from those noted in the ischial tuberosity" (Fig 73)

Five days after admission the ischium was resected subperiosteally Microscopically typical tuberculosis was found Two weeks after operation the wound healed by primary union and the patient was permitted to leave the hospital

With the present development of antituberculosis drugs, such as isoniazid, para aminosalicylic acid and streptomycin, the whole problem of tuberculous osteitis, as of tuberculosis in general is entering a new phase in which a biological approach is possible. A new drug cycloserine has but recently been described and doubtless others will be developed Final evaluation of

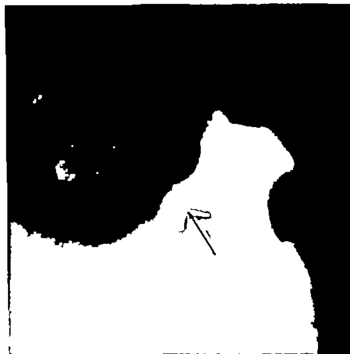


FIG. 73 Case R. R. There is a small area of necrosis on the posterior aspect of the tuberosity with a mild periosteal reaction. (Courtesy of Dr J Buchman.)

these drugs must await their more mature appraisal. Even though the ultimate verdict will unquestionably be favorable, the need for surgical assistance in the evacuation of abscesses and the removal of such sequestra as may form will persist. The earlier it is performed (and certainly before fistulization of the abscess has occurred) the better will be the result

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CHAPTER 11

Periischial Soft Tissue Injury

EXCLUSIVE OF INJURIES to the pelvic viscera which are usually associated with extensive damage to the ischium, injuries of the more immediate periischial soft tissues have been described. Chief among these are those to the gluteal arteries and the sciatic nerve.[12] Because of their relatively protected position beneath the mass of the gluteus maximus muscle however such lesions are uncommon. They have been more frequently encountered as a result of penetrating injuries sustained under war conditions, but have also been observed to occur in civil life in consequence of stab wounds or even after apparently simple blows on the buttocks.

INJURIES TO VESSELS

Injury to the superior gluteal artery is three to four times more frequent than injury to the inferior gluteal vessel because of the additional protection afforded by the sacrotuberous ligament and the bony pelvis. Injury to the inferior gluteal artery does occur however and may occasionally be confused with pathological processes occurring within the ischiorectal fossa.

Tillaux[11] reported a case in which a supposed ischiorectal fossa abscess occurred two weeks after a fracture of the femur This was incised and found to be a hematoma caused by a bone spicule that had perforated the inferior gluteal artery Battle described a case that resulted from a fall on the right buttock. The patient complained of pain and was hospitalized because of the appearance of a pulsating mass in the buttock. Operation disclosed a hematoma caused by rupture of the inferior gluteal artery A somewhat similar case, caused by a crushing injury was reported by Servier[1]

On the other hand, bleeding from either of the gluteal vessels has been reported following infections within the ischiorectal fossa. Koenig[8] reported a case in which erosion of the superior gluteal artery followed upon the formation of a "cold abscess" in the left gluteal region.

Apart from actual injury to the vessel wall, cases of aneurysm of the gluteal vessels have been described.[2,4,5,12] Willet[13] described an aneurysm of the gluteal vessels following embolization in a patient with heart disease. In three other cases, in which the inferior gluteal artery was continuous with the popliteal (ischiopopliteal artery) the aneurysmal dilatation was noted to extend down to the level of the knee joint. Guillaumet[6] reported a case that developed eight months after the patient had fallen a distance of about six feet. The appearance of pain and swelling in the right buttock led to aspiration of the mass, operation, and later death

Depending upon the nature and extent of the arterial injury hemorrhage from either of the gluteal vessels may be profuse and sufficiently severe to threaten life immediately or it may occur gradually and give rise to a slowly increasing mass in the gluteal region The hematoma thus formed may give rise to pain owing to compression of the sciatic nerve and may if secondarily infected, lead to a severe sepsis. Even in the absence of external bleeding the possibility of damage to the gluteal arteries must always be kept in mind in any injury to the gluteal region.

Where brisk bleeding from a penetrating wound in the neighborhood of the gluteal arteries is present, it is unquestionably safest to enlarge the external wound for the purpose of securing adequate hemostasis. This is not always a simple procedure, especially if the main branch of either artery is involved. Normal retraction of the artery to within the pelvis may render it inaccessible through the external wound The difficulty arises in cases in which there is no external bleeding but in which the development of a pulsating swelling suggests the possibility of an aneurysm.

The possibility of an aneurysm or abnormal arteriovenous communication must be contemplated in all cases where swelling has followed an injury to the buttock. In small aneurysmal sacs or in those with thick walls the characteristic stigmata of aneurysms may be absent. The presence of a pulsating mass or the existence of a systolic murmur that disappears on compression of the iliac artery is, of course, suggestive but not pathognomonic These symptoms may be present in other pulsating tumors or in tense abscesses that transmit pulsation. Similarly pain or pressure paralysis of the sciatic nerve may appear as signs of both solid tumors and aneurysmal dilatations.

The treatment consists of complete excision after careful ligation of all arterial communications. This is not a simple procedure and is accompanied by a high operative mortality Battle[1] and Dennis,[4] who reported on such cases, call particular attention to the necessity of controlling hemorrhage by

preliminary compression of the iliac artery through a transperitoneal incision. After the iliac artery has been tied complete excision of the aneurysm may be undertaken. Direct surgical approach to the gluteal arteries may be made through muscle splitting incisions in the direction of the fibers of the gluteus maximus muscle. The superior gluteal artery is to be sought above the level of the pyriformis muscle and the inferior gluteal artery below the lower border of this muscle (Fig. 7).

INJURIES TO NERVES

Nerve injuries resulting from affections of the ischium involve primarily the sciatic nerve. Pain in the distribution of the obturator nerve is usually of a referred nature and has been described in lesions of the obturator foramen and in conditions localized to the ischiopubic junction. Symptoms referable to the pudendal nerves are extremely rare, though they have been described in fractures of the ischiopubic region and in the so-called ischiopubic osteochondritides. In at least one case of ischiopubic abscess, priapism was the most distressing symptom. Whether this is to be attributed to a nerve irritation or to tension within the sheath of the ischiocavernosus muscle is not clear.

In all instances where the symptoms are of a referred nature, they usually subside with cure of the underlying pathology. In the sciatic nerve, permanent peroneal palsy may persist even after healing of the fracture that precipitated its appearance. Although the abrupt onset of symptoms may suggest actual severance of the continuity of the nerve exploration of the sciatic nerve at a later time may reveal no such evidence. Where the signs of peroneal palsy persist, treatment must be directed toward the relief of a paralytic dropped foot by operative orthopedic intervention. Where pain is the predominant symptom, relief may occasionally be obtained by stretching of the sciatic nerve or by epidural injections of local anesthetic agents.

INJURIES TO MUSCULATURE

All affections of the ischium are associated with some degree of involvement of the periischial musculature. Hemorrhage is frequently profuse and may be followed by organization or calcification producing a tumor mass that may resemble a neoplasm (Hancock[*]). Infection of hematomata in this region may present complicated problems because of the anatomical arrangement of the fascia, which extends into the thigh. It is not uncommon for infection of the ischium to be complicated by involvement of the posterior compartment of the thigh with the development of a secondary abscess extending as low down as the knee. In such event, the original source of infec-

tion of the ischium must be evacuated as well as the secondary abscess in the thigh.

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CHAPTER 12

Ischial Bursitis

SOME STUDENTS HAVE questioned the possibility of mechanical irritation to the region of the ischial tuberosity because of the cushioning effect of the gluteus maximus muscle In the erect position this muscle does indeed cover the ischial tuberosity On the other hand, it must be recalled that in the seated position the front of the pelvis is tilted upward and, as a consequence, the ischial tuberosity moves downward becomes uncovered by the gluteus maximus muscle, and comes into immediate, almost subcutaneous contact with the seat. Direct pressure is so great that in certain monkeys, as has been previously mentioned, it leads to a broadening and flattening of the ischial tuberosity Precisely the same observation has been made in humans con demned to prolonged assumption of the sitting position.

Regnault[13] noted that although the ischium is not usually flattened in humans, it may under certain circumstances acquire the same conformation as characterizes the ischia of monkeys. He reported three cases in point. (1) an old lady both of whose hips had become ankylosed in flexion as a result of infectious arthritis, and whose ischia "presented a flattened surface 26 millimeters wide, which extended beyond the ischial body and was continu ous with the ascending ramus which was itself flattened so that it presented a superior and inferior surface rather than an anterior and posterior surface which is normal" (2) a case that followed tuberculous ankylosis of both hips and (3) a similar deformity seen by Dr Marie following ankylosis of both hips.

While the significance of direct pressure cannot be denied, it seems pe culiar that relatively so few cases of bursitis have come to attention in the literature Heineke,[7] who was particularly interested in this, communicated with Wenzel von Gruber about it The famous St. Petersburg anatomist ex pressed the opinion that the relative infrequency of clinically observed bur

sitis was to be found in the relative inconstancy of the ischial bursae. He noted that in all his dissections he had encountered the ischial bursa only once in children under the age of ten years. Domeny[3] on the other hand, categorically disagreed with von Gruber and expressed the opinion that deep bursae are not adventitious but are laid down embryologically. In the face *of these mutually exclusive opinions, no satisfactory explanation of the relative* infrequence of the condition has been offered.

Inflammation of the bursal tissues about the ischial tuberosity has been reported in the literature under the title of "hygroma." Though relatively rare, such cases as have been studied are well documented with respect to etiology, histological appearance and treatment. On the other hand, there is a second form of ischial bursitis that appears formerly to have been common and to have appeared so commonly in association with specific occupations as to have acquired the familiar designation of "weaver's bottom,"[15] Lighterman's disease, or lathe turners' bottom. It appears that two types of ischial bursitis may be recognized: (1) the cystic hygroma and (2) occupational bursitides.

Hygromata of the ischial bursa have been the subject of larger communications by Bungner, Dupont,[4] Friend,[6] Heineke,[7] Küster,[8] Mauersberg,[10] Müller,[11] Nicaise,[12] Chassaignac,[3] and Schuchardt.[14] Up to 1896 Mauersberg was able to collect only ten cases of ischial hygromata from the literature and only a few cases have been added since that time. In his 1930 report of fifty-five cases of cystic hygromata, Jones[9] does not mention a single case involving the ischial bursa. He notes, however, that "trauma, both acute and long continued plays a significant part in the etiology, whereas infection has a doubtful place. This is in conformity with the histories obtained by other *observers in cases of ischial hygromata. In all, there was a history of a fall,* a blow on the ischium, prolonged horseback riding, or the irritation of a leg prosthesis following amputation.

The onset of pain, especially on sitting, followed at a variable time after trauma. It was invariably the appearance of tumefaction, either unilateral or bilateral, that led to ultimate clinical recognition and surgical intervention. In some instances, the tumor was relatively small and attached directly to the ischial tuberosity. In one case, the cystic mass extended down the back of the thigh almost to the knee. Aspiration of the mass yielded a fibrinous, sanguinolent fluid.

In those cases in which the mass was extirpated, the gross and histologic appearance of the wall of the cyst was identical with that described by Jones for hygromata of other anatomical derivation. The cyst wall consisted of several layers, the outermost of which was firm connective tissue. The innermost lining wall presented varying appearances of necrotic tissue, rice bodies, and villous proliferations.

Though various forms of treatment have been suggested in the past, excision is unquestionably the procedure of choice. The follow-up studies made of hygromata submitted to excision have shown no tendency toward recurrence.

The clinical picture of the cystic hygromata differs entirely from that which has been designated as weaver's bottom.[14] Beyond casual reference to this second form of ischial bursitis, no accurate description of the condition has been found in the literature. As in many other instances of excessive familiarity there is an almost contemptuous disregard of the condition. This may be explicable on the ground that these patients seldom presented clear-



FIG. 74 A faint shadow is seen just posterior to the ischial tuberosity. This is characteristic of ischial bursitis and must be differentiated from the shadow seen in ischial apophysiolysis.

cut surgical indications and the opportunity of exploring the condition has thus been overlooked.

Sutton[15] in discussing weaver's bottom stated that "when a subcutaneous bursa attains an abnormal size it is invariably due to pressure associated with particular occupations . . . weavers and lighter men from prolonged sitting on hard seats suffer from bursae over their ischial tuberosities." Hein in a reference that could not be verified, is reported to have described a similar condition as common among lathe workers. While weaver's bottom has largely disappeared with the disappearance of hand weaving there are still many nonlightermen or lathe workers who in the arduous pursuit of sport have been forced to spend painful hours on the hard seat of a rowboat and can attest to the reality of the condition. They do not disparage the importance of their ischialgia nor deny themselves the comfort of a cushioned seat.

This affection is characterized by pain and localized tenderness on pressure over the ischial tuberosity. The pain is typically present on sitting. Apart from this symptom the only diagnostic sign is the appearance of a radiopaque shadow in the region of the ischial tuberosity (Fig 74). It is undoubtedly the lack of this diagnostic medium in the past that accounts for the recognition of the clinical syndrome without any indication for surgical intervention. It is unfortunate that the significance of the shadow is still



Fig. 75 Circumscribed roentgen opacities that overlap the shadow of the ischial tuberosity are aligned in the direction of the hamstring muscles arising from the tuberosity

misapprehended under the noncommittal diagnosis of "periischial calcification" as in the following case.

S. S male, aged sixty-three, had been struck in the left buttock when an automobile backed into him. There was no ecchymosis but the patient complained of pain in the buttock. This pain was made worse on sitting and radiated down the back of the left thigh to the knee. Elevation of the leg putting on the shoes, or making a quick step caused an exacerbation of pain. The patient had been treated by diathermia for a period of about three weeks without any amelioration of the symptoms. Examination disclosed tenderness localized over the ischial tuberosity with a definite spasm of the hamstring muscles on this side. X ray (Fig 75) revealed a shadow that was diagnosed as "periischial calcification" Operation was advised but refused by the patient. Diathermia was continued by his local physician for a period of about six months after which the pain disappeared.

The opportunity of examining the pathology in these cases was afforded by a case seen by Dr S Kleinberg through whose courtesy the case is reported.

B. C., female, aged fifty-eight, gave a history of intermittent pain in the region of the left ischial tuberosity over a period of two years. The pain, made worse when seated with the left thigh flexed, radiated down the leg to the calf Apart from tenderness on deep pressure over the tuberosity of the ischium, all clinical findings were negative The x ray (Fig 76) was reported as showing calcareous deposits within the ischial bursa on the left side and excision was decided upon.



Fig. 76. Radiopacity is seen in the characteristic location for an ischial bursitis. At operation, this was found to be due to the presence of a "creamy calcareous material in the deep ischial bursa. (Courtesy of Dr S Kleinberg)

Operation was performed in the lithotomy position An oblique incision was made and on cutting through the fascia and the gluteal aponeurosis a bursal cavity in the region of the attachment of the hamstring muscles close to the ischium was entered. A moderate amount of creamy calcareous material extruded. The sac was excised and the wound closed in layers with a pressure dressing Culture of the material was reported to be bacteriologically sterile Postoperative x ray disclosed complete absence of the radiopaque shadow The patient was relieved of her symptoms.

The findings in this instance suggest that the pathology in cases of weaver s bottom is entirely different from that of the hygromata and is similar to that seen about other tendon insertions, peritrochanteric bursitis subacromial bursitis, radiohumeral bursitis. It may well be that the reason for the poverty of reports on this condition in the literature is that the condition may be transitory in nature. Where there is no evidence of radiopacity ischialgia is

the main symptom. Where the pain persists, x ray should be made to determine the existence of a perischial calcification.

Though excision may give complete relief of symptoms, surgery would seem to the court of last resort Protection of the irritated area, cushioning of hard seats, local heat, and injections of a local anesthesia are suggested as methods of treatment prior to surgery It is important to be aware of the condition in the differential diagnosis of conditions characterized by sciatic radiation of pain

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CHAPTER 13

Ischial Decubitus Ulcers

DESPITE MOST METICULOUS nursing care, the development of decubitus ulcers is frequently unavoidable in patients long confined to bed or the wheel chair. Although they may develop at any point of prolonged pressure, they are usually found over bony prominences, particularly the sacrum, the trochanters, the ischial tuberosity, the anterior iliac spines, and the tuberosity of the os calcis.

While pressure against unyielding bony prominences is the underlying mechanism in the development of decubitus ulcers, a number of other known factors play a part in their appearance. Chief among these are the loss of tissue resistance that results from the paralytic vasodilatation associated with spinal shock and interruption of spinal vasomotor control, the loss of sensation that normally leads to change in position when prolonged pressure threatens ischemia, and moisture that leads to maceration and ultimate breakdown of the skin.

Ischial decubitus ulcers may develop early in the course of a paraplegia or late, after the patient is ambulant on braces or in a wheel chair. At the outset, the skin over the ischial tuberosity becomes reddened. Later there is a swelling over the tuberosity, the bursa becomes thickened and inflamed, and can be readily palpated. If pressure continues the skin may become necrotic, leaving a granulating area over the intact bursa. If, however, the bursal wall is ruptured, a sinus tract develops and the bursa almost invariably becomes secondarily infected. As a result of the bursal infection, the underlying bone is involved. This response is at first limited to the periosteal covering but later leads to a true osteomyelitis of the ischium (Fig. 77).

Though the superficial ulcer may be relatively small, widespread necrosis and infection may exist in the deeper tissues. Guttman[3] has noted that infection may spread in three different directions:

the main symptom. Where the pain persists, x ray should be made to determine the existence of a perischial calcification.

Though excision may give complete relief of symptoms, surgery would seem to the court of last resort. Protection of the irritated area, cushioning of hard seats, local heat, and injections of a local anesthesia are suggested as methods of treatment prior to surgery It is important to be aware of the condition in the differential diagnosis of conditions characterized by sciatic radiation of pain

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Though the superficial ulcer may be relatively small, widespread necrosis and infection

(a) along the ischial ramus, the infection spreading as a rule in a lat direction towards the hip joint, although it may very rarely also spread med towards the pubis, (b) down along the posterior fascial compartment of thigh, sometimes as far as the knee, in walking cases, (c) forward into region of the groin. This direction of spread is associated with prolonged continuous nursing in the prone position. The patient will develop a swellin the groin, which will *either perforate spontaneously or reveal pus on aspira* This type of spread of infection is particularly dangerous as it is most obstu to therapeutic measures.

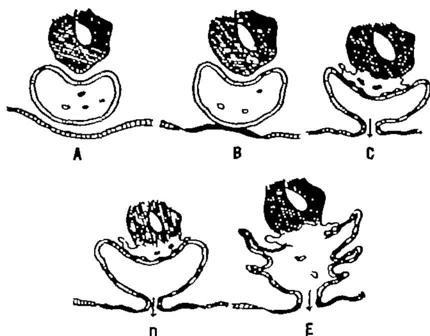


Fig. 77 Stages in the formation of ischial pressure sores. *A* intact bursa *B* skin necrosis overlying intact bursa, *C* sinus development with intact skin *D* sinus tract, necrotic skin and involvement of the under lying bone *E* osteomyelitis of ischium with ramifying tracts (Reproduced from Yoeman, M. P and Hardy A. G., Pathology and treatment of pressure sores in paraplegics, *Brit J Plast Surg* 7 179 1954)

As one would expect, septic involvement of the bone naturally has its rep cussions on the hemopoietic mechanisms, resulting in more or less severe anem The tragedy in these cases is that as a rule the septic complications followi pressure sores progress silently—a lingering or creeping type of sepsis without r of temperature. There is hardly any need to mention what disastrous effe this septic condition has on the nitrogen balance of the patient. In fact, we ha admitted paraplegics with pressure sores in such an extreme state of malnutriti that it could be compared only with that of the inmates of the Belsen Camp.

Once they have developed, these ulcers are chronic, may assume extensi *proportions, and usually resist all forms of conservative therapy* (Fig 78 They invariably necessitate arduous and painful surgical dressings that a discouraging both to the patient and to the surgeon in the degree to whic

they are unsuccessful Apart from the discomfort of the patient the ulcerating areas act as portals of infection through which serum proteins are lost so that these patients go into profound negative nitrogen balance become emaciated and anemic This establishes a dilemma most difficult to resolve On the one hand, it is almost impossible to restore nitrogen balance in such patients until the wound has been closed On the other hand, the plastic surgery necessary to effect such closure is not readily tolerated by these patients until they can be brought into better preoperative condition by high calorie and high protein feeding and by blood transfusions. An effort may be made to facilitate nitrogen retention by the administration of testosterone or synthetic androgenlike hormones along with this regimen.



FIG. 78. Typical appearance of bilateral ischial pressure sores. There is extensive undermining of the sore on the right side. (Reproduced from Blocksma, R., Kostrubala, J G., and Greeley P W., Surgical repair in decubitus ulcers in paraplegics. *Plast & Reconstruct Surg* 4 123 1949)

By all means, the best treatment is prophylaxis. The paraplegic patient should be turned every two hours so as to avoid the possibility of prolonged pressure. If evidence of skin pressure appears, the patient should be placed in other positions until the skin regains its normal circulation. If necrosis without involvement of the underlying bursa has occurred, the necrotic area should be excised, the skin should be approximated, and direct suture attempted If however the bursa has been opened complete excision of all necrotic tissue including the entire bursa must be accomplished Failure completely to excise the infected bursa inevitably leads to recurrence of the ulcer

In the absence of any bone involvement, wide excision followed by skin flap coverage of the defect frequently leads to primary closure of the wound (Fig 79) Experience however has established the fact that when subject to

trauma or renewed pressure, the new skin ulcerates in exactly the same manner as had the old with re-establishment of the original condition.

It was as a result of the knowledge gained in the treatment of relatively large numbers of war wounded paraplegics that attention was directed to the importance of the underlying bone. Even in the absence of evident roentgenographic signs, Blocksma, Kostrubala, and Greely[1] state that "in almost all decubitus ulcers of several months duration, the underlying bone is definitely diseased whereas in the more recent ulcers there may be little or no bone involvement. Our pathology reports show degeneration and/or fibrosis of bone 51.8 percent, osteitis and/or osteomyelitis 24.1 percent. No



FIG. 79 Ischial sore before operation. There was no involvement of the ischium and excision of the ulcer with closure by means of a rotation flap was possible. (Reproduced from Yeoman, M. P., and Hardy, A. G. Pathology and treatment of pressure sores in paraplegics. *Brit. J. Plast. Surg.* 7:179, 1954.)

disease of bone reported 24.1 percent" (Fig. 80). In those in whom recumbency in bed was maintained the ulcerations occurred predominantly over the sacrum, the femoral trochanters, or the anterior iliac spines, depending upon whether the patient was supine or prone. With the development of the rehabilitation program and the assumption of the seated position a sharp rise in the incidence of ischial ulcers was noted.

Because of the satisfactory results obtained by resection of the femoral trochanter and the underlying sacrum, the desirability of removing the bony prominence of the ischium appeared clearly indicated and was undertaken by Kostrubala and Greely.[1,3] In the beginning they "began by amputating a portion of the ischial tuberosity and then covering the defect with gluteal and biceps muscle flaps and a local rotation flap from the posterior surface of the thigh, covering the donor area with a split thickness skin graft. The results were not satisfactory in all cases, however, because (1) a bony prominence remained as a potential hazard in the production of a new ulcer and

(7) incomplete excision of diseased bone led to the recurrence of sinus tracts." In general the results in what has been called old type ischial closure may be judged from the fact that in operations performed on forty-eight ulcers, 62.5 per cent showed healing after one operation an additional 18 7 per cent closure after two operations an additional 12 5 per cent after three operations, and 6.3 per cent after the fourth operation Because of this they were led to complete excision of the ischium



FIG. 80. Osteomyelitis of the ischium in bilateral ischial decubiti. (Reproduced from Blocksma, R., Kostrubala, J G and Greeley P W Surgical repair in decubitus ulcers in paraplegics. *Plast & Reconstruct Surg 4* 123 1949)

A new and more radical method of treating the ischial decubiti has proved simpler and more satisfactory After excision of the ulcer Gigli saws are passed through the obturator foremen and a complete ostectomy of the ischial tuberosity is performed. The ischial rami are trimmed further with a Sauerbruch rongeur the lateral excision continuing until the bony fulcrum supporting the internus muscles has been removed The obturator internus muscle is then fanned out and then sutured over the lateral ramus to the obturator externus and to the cut origin of the biceps femoris muscle. It is then usually possible to close the wound by simple primary closure using local tissue to fill in the entire defect without the use of any flaps.

Though the exact steps in the procedure are not described, it appears that these authors employed essentially the same technic as was reported by the present writer[4] in 1935 The method of resection of the bone as well as the

area resected are evidently identical. The only difference would seer in the approach to the bone through the already existing defect in the ated skin rather than through the standard skin incision. Because of t *that bone was exposed through an infected area, preoperative prepara* means of Sulfasuxidine, 3 Gm. every six hours, penicillin, etc. employed.

Following operation, the sitting patient is now able to carry his body on bony prominences which are covered with a very ample padding of fat and skin and the necessity for the use of complicated muscle flaps is ol The patients who are able to walk on braces have shown no evidence of instability. Complications have been few and not serious. Healing ti materially decreased. *Of this group only 14 percent required an additio* to effect a comfortable closure. The ulcers in this group have recurre repair

The results reported by these authors in 97 operations on 85 ulcer 88 2 per cent closed after the first operation, 10 6 per cent closed af second operation, and an additional 1 2 per cent after three or operations.

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CHAPTER 14

Tumors of the Ischium

It is difficult to estimate the exact incidence of isolated tumors of the ischium. While tumors of the pelvic girdle cannot be considered as rare, tumors of the ischium alone are relatively unusual and appear in the literature largely as individual case records. In a series of forty-one cases of pelvic girdle tumors collected from the five year records of two hospitals, Bick[4] noted only one as arising in the ischium. Braunstein[10] collected ten cases of pelvic fibroma of which three were located in or near the ischium. Up to 1905 Tillmanns[43] found the reports of ninety-eight cases of chondroma or osteoma in the literature. Only four cases were located in the ischium and, in an additional three cases, the tumor was found involving both the ischium and the pubis with probable site of origin in the ischiopubic junction. In one hundred sixteen cases of pelvic sarcoma, none was found in the ischium alone.

Isolated tumors of the ischium may be either primary or secondary. The primary tumors are of mesodermal origin and may be either benign or malignant. The secondary tumors are usually metastatic and of ectodermal origin. Among the more important contributions on this subject in the literature there are reports of benign lipomas, fibromas, chondromas, osteomas, ossifying hematoma, exostoses, osteoclastomas, malignant sarcomas of varying cellular types, Ewing's tumor, myeloma, and metastatic carcinomas.

BENIGN TUMORS

Hancock[24] described an unusual "ossifying tumor" in a woman of forty who, as she fell to the ground in a sitting position, noted a snapping sensation in the region of the ischium. Shortly thereafter she perceived a swelling the size of a marble in the ischial region. Within six weeks, this had enlarged to the size of an orange, caused pain on standing and made sitting impossible

without the interposition of a cushion. At operation, a large mass of ossific tissue internal to the biceps and posterior to the triceps was found near the ischial tuberosity. This was attributed by Hancock to organization of a hematoma following rupture of the biceps muscle.

Bilhaut[8] reported the case of a seven year-old female in whom a soft, almost fluctuating lipoma in the ischial region had been noted since birth.



FIG. 81 Congenital lipoma, right ischial region. (Reproduced from Bilhaut, M., Lipome congénitale de la région ischiatique droite *Annales de Chirurgie orthopédique* 22 65 1909.)

The tumor had grown slowly and had gradually become painful so that the child had difficulty in sitting. It was removed without difficulty and with complete subsidence of symptoms (Fig. 81). Kirmisson[24] reported the case of a twenty three month-old infant in whom a small tumor had been noted in the left gluteal region at the age of five months. Because of its rapid growth, this was removed and found to be a well encapsulated and regularly lobulated tumor. As in Bilhaut's case this lipoma was removed without trouble and with complete cure.

Fibromas in the region of the ischium have been reported by Braun, Nicaise,[13] Fayrer,[20] Tansini,[40] Tillaux,[8] and others. These may arise either

from the cambium or the fibrous layers of the periosteum In the case described by Gould[21] the tumor was attributed to a fall down stairs and occasioned pain radiating down the left leg for a period of two years. When first seen, it extended from the posterior aspect of the great trochanter around the hip to project along the inner side of the hip The mass was firm rounded, and freely movable on the hip At operation it was found to be attached to the ischium and involved the sciatic nerve a portion of which had to be sacrificed to remove the tumor

Under the term *exostoses* there have been grouped a number of different cases that might specifically be designated as chondromas, osteomas, and



Fig. 82 Exostosis of posterolateral aspect of right ischial tuberosity (Reproduced from Fauvel, E., Exostoses de l'Ischion *Thèse de Paris* 1927)

osteochondromas. Fauvel,[19] who has made a special study of these tumors, noted that they are usually covered by bursae and may be divided into two types, the osteogenic and the nonosteogenic. The osteogenic type are usually multiple, develop on the diaphyseal side of an epiphysis during the growth of a child, and cease growing when the child stops growing They are to be differentiated from the nonosteogenic exostoses, which are usually solitary and frequently posttraumatic or postinfectious. They may appear at any age and may arise either in the diaphyseal or epiphyseal regions. These tumors occur in the ischium less often than anywhere else in the pelvis and are almost never found on the outer wall of the pelvis (Fig 82) They frequently give an antecedent history of injury but in one case reported by Lenormant[24] apparently followed an attack of typhoid fever

Regnoli,[27] Delbeau,[16] Djørup,[17] Ferrario,[21] Billroth,[8] and Tillmanns[43] reported cases in which the tumor was located in the body of the ischium (Fig 83) Lenormant's case involved the inner aspect of the ischium. Three additional cases reported by Aievoli,[1] Gillette,[22] Marcuse,[30] and Wilms[46] involved both the ischium and pubis and probably arose from the ischiopubic junction. In a similar case reported by Damourette,[15] urinary tract symptoms were noted.

Two cases of ischial exostosis reported by Stadfelt[39] are said to have resulted in dystociae, though the major cause of this complication appears to arise as a consequence of tumors located elsewhere than in the ischium. West[45] reported the case of a twenty five year-old Para II in whom a hard, painless lump had been present in the vagina for a period of about two years. This mass completely obstructed the pelvic outlet and had to be removed before normal delivery was possible. The pathologist reported a simple osteoma. Two months after delivery examination disclosed a firm, fibrous band extending from the pubis to the tuberosity of the ischium. There was no evidence of recurrence and no impairment of function.



FIG. 83 Osteochondroma of ischial tuberosity (Reproduced from Djørup, Fr., Om to Tilfælde of avulsier n os ischii. *Hospitalstid* 75 467 193_.)

The main symptomatology evoked by these tumors is pain, either localized to the site of the tumor or radiating along the course of the sciatic nerve. The local pain has been attributed to inflammation of the bursa that frequently covers the top of these tumors The radiating pain has been attributed to direct pressure upon the sciatic nerve.

The occurrence of sciatic pain is probably the most common of the presenting symptoms of tumors of the ischium and may be mistaken for pain originating in a prolapsed lumbar intervertebral disc. In the ischium the pain is most often due to compression or actual involvement of the sciatic nerve. Fauvel has called attention to the fact that a differentiation may be made between this pain and that due to discal or low back injuries. Pain resulting from conditions in the lumbar spine is radicular in nature and is accentuated by coughing or sneezing as contrasted with "sciatica" of trun-

cular origin, which is not usually associated with paresthesias but may show signs of peripheral nerve involvement

The treatment is by excision, including all the base of the tumor No cases of metastases have been reported of tumors situated in this location, though such metastases have been noted in other pelvic tumors of this type.

Benign osteoclastoma of the ischium has been described by Nissen[11] and by Brandsma.[8] Nissen's case appeared in a female of thirty seven who had complained of pain for a period of about eleven months. The whole of the



Fig. 84 Osteoclastoma of ischium (Reproduced from Brandsma, A. G., Destruction of the ischium by giant cell tumor *Neder tijd v Geneesk 85* 3460 1941)

ischium from the spine to the pubis was involved The patient was treated by means of radium and was able to resume her full duties as a housekeeper within four months of the beginning of treatment. Brandsma's case was that of a man of forty who also presented symptoms of pain and limitation of motion in the hip The x ray revealed complete disappearance of the ischium from the spine to the pubis. Treatment was by resection with complete subsidence of symptoms (Figs 84 85)

Osteoid osteoma of the ischium does not appear as such in the literature. In 1937 Raspé[24] reported a case history that he described as a rare change in the ischium resulting from sport." Though the facts are not entirely clear they more closely conform to the clinical picture of osteoid osteoma



Fig. 85 Microscopic section of tumor in Figure 84



Fig. 86. Osteoid osteoma of the ischium (Courtesy of Dr J Mintz)

than any other condition A completely typical case is presented here through the courtesy of Dr J Mintz

The patient a woman of thirty three complained of persistent discomfort in the perineum that was made worse on walking Apart from slight limitation of internal rotation of the left hip and the roentgenogram (Fig 86) no objective findings could be elicited The lesion was exenterated some two months after onset of the symptoms. Unfortunately the specimen was badly macerated during the surgical procedure so that the pathologist could only report that in "one tissue fragment a small zone of osseous tissue reconstruction may represent the outer most peripheral border of an osteoid osteoma" Despite this, the clinical picture and particularly the x ray of the lesion are so typical of the condition as originally



FIG. 87 Cyst of ischium. (Reproduced from New England M J 245 379 1951)

described by Milch[n] and subsequently by Jaffee[m] that the diagnosis of osteoid osteoma may be accepted. The patient made a complete and uneventful recovery following removal of the lesion

The only case of a *cyst of the ischium* thus far reported appeared in the case records of the Massachusetts General Hospital.[14] The patient, a young man of seventeen, had turned somersault when he lost his right ski while water skiing He complained of increasing pain in the left thigh and had difficulty in walking Flexion, internal rotation and abduction were limited by pain that radiated into the inguinal and gluteal regions. There was no tenderness on external palpation but rectal examination disclosed a slightly tender bulge on the left side. X ray (Fig 87) revealed a cystic area about 7 cm long and 4 5 cm. wide lying in the ischium and extending up to

the lower margin of the acetabulum The bone was greatly expanded, thinned, and was the site of a fracture line that extended from its superior pole to the lateral aspect of the cyst. There was no trabeculation, no appreciable involvement of neighboring bone, or significant periosteal new bone formation. Though there was a mottled calcification in the soft tissues about the bone, there was no evidence of tumor formation At operation the cyst was found filled with fluid

An unusual benign chondroblastoma of the ischium was reported by Kunkel, Dahlin, and Young[27]

MALIGNANT TUMORS

Primary malignant tumors of the ischium are generically sarcomas of various cell types and various degrees of malignancy but *Ewing's tumor*[12] and *solitary myeloma*[7] have been reported



Fig. 88 Ewing's tumor of the ischium. (Courtesy of the Armed Forces Institute of Pathology)

Ewing's tumor usually occurs in individuals below the age of twenty and may be associated with fever chills, and an elevated leucocyte count simulating an acute infectious process. The roentgenogram can easily be mistaken for that of an acute osteomyelitis (Fig 88) *Myeloma* usually occurs after the fourth decade of life and may be single or multiple. Cutler[13] and his co-workers emphasize the fact that the solitary type of myeloma is to be differentiated from the more common multiple type. They note that the solitary form may be further subdivided into two clinical types one in which the primarily solitary tumor later becomes generalized, and a second,



FIG. 89 Solitary myeloma of the ischium. (Reproduced from Blum, S. D., Solitary myeloma of bone. *Am. J Roentgenol* 57 239 1947)

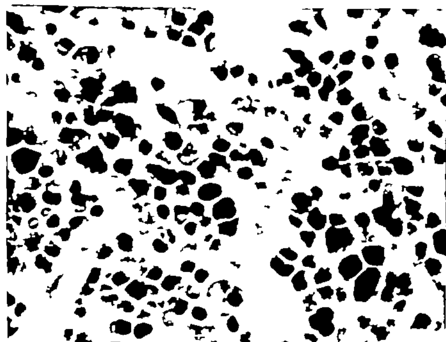


FIG. 90 Microscopic section of myeloma seen in Figure 89

in which the tumor remains localized for longer periods of time (four to twelve years) This concept is extremely important since, in certain cases at least, it holds out the hope of cure by radical removal of the involved area. Blum[7] states that, up to 1947 the case he reported was the only one of isolated myeloma of the ischium in the literature The patient was a man of

fifty who complained of sciatic radiation of pain. X ray involved a destructive osteolytic lesion involving practically the entire right ischium" (Fig 89) This patient was treated by radiation therapy in the belief that the tumor was an osteogenic sarcoma. Biopsy was not performed until after the radiation therapy had been started (Fig 90) Microscopic section showed "large masses of plasma cells, fairly large in size and round and oval in shape The nuclei are eccentric and the cytoplasm was light blue and granular The nuclei contained one to two nuclei and the chromatin was arranged *in a spokelike fashion*." Hemipelvectomy was performed but the patient subsequently died as a result of a postoperative infection.



FIG. 91 Fibrosarcoma of the ischium. (Reproduced from Belot, L., and Nahan, L., Volummeux fibro-sarcome a joint de départ ischiatique *Presse méd* 44 851 1936.)

Periosteal sarcoma of the ischium has been described by Zacharae,[41] *round cell sarcoma* by Machell,[28] *fibrosarcoma* by Belot and Nahan[3] (Fig 91), Weir[44] and Brook,[11] *fibromyxochondra sarcoma* by Crumpacker[12] *osteogenic sarcomas* by Ticozzi[41] Nogier[34] and Dorrell and Thomas.[8] *Reticulum cell sarcoma* is probably the most uncommon of all the sarcomas but does occasionally occur as the following case illustrates.

W S., male, aged sixty complained of pain in the right hip for three and a half months. There was no history of trauma. The pain became progressively worse and there was slight limitation of motion in the hip. X rays of the hip, pelvis, and back taken after admission to the hospital were originally reported to be negative but subsequent x ray films taken about one month later were reported to show an osteolytic lesion in the ischium (Fig 92) A biopsy section, taken from the ischium, was reported to show "a network of reticulum cells which are actively laying down reticulum in varying degrees" (Fig 93) Following the biopsy the patient experienced some relief of pain but despite large doses of x ray he gradually went down hill and died

In the case of *fibrosarcoma* reported by Brook, the tumor consisted of organized fibrous tissue with areas of fibrosarcoma especially in relation to the bony tissue—order of malignancy low This patient was reported to be alive and symptom free three years after operation, which consisted simply of curettage and radium treatment. There may be some question whether this case should be included among the frankly malignant cases. If so it



Fig. 9 Reticulum cell sarcoma of the ischium.

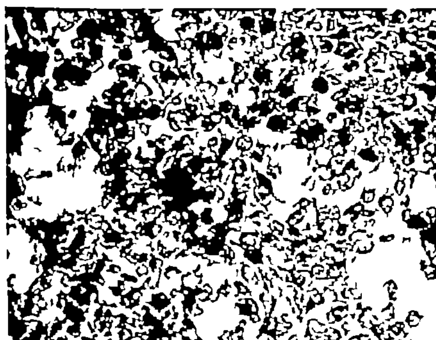


Fig. 93 Microscopic section of tumor seen in Figure 92

appears that with this exception, the outlook is poor for all these cases regardless of the histological appearance of the tumor or of the treatment that is instituted.

Many of these cases, whether benign or malignant, present some history that raises the question of relationship of trauma to the appearance of the tumor Because of the histological similarity that may exist between ossifying hematoma, osteoma, and sarcoma, some have maintained that trauma is the etiologic factor responsible for the appearance of the tumor Others are of the opinion that the trauma may act to stimulate a pre-existing nidus to growth, may accelerate the rate of growth of a previously existing tumor or may merely serve to direct attention to a tumor already present.

In many instances, there appears to be a well authenticated relationship between injury and the appearance of either benign or malignant tumors. The determination of the matter is not infreqeuntly the basis for legal action and instances are on record where the courts have affirmatively indicated their belief in the relationship It would seem, however that the presumptive basis for such an affirmation should be on the satisfaction of Segond's postulates (1) that the tumor arise within a reasonable time after the alleged injury (2) that it appear at the site of the alleged injury and (3) that it be progressive from the time of the injury [34]

The question of the relationship of trauma does not arise in the case of secondary metastatic involvement of the ischium by a malignant tumor While they may be mesodermal in origin, the majority would seem to be ectodermal and arise in malignant growths of the breast, the kidney the thyroid, lung or prostate. Of forty three lesions of the ischium in the files of the Armed Forces Institute of Pathology one was listed as being a secondary fibrosarcoma, one as a secondary adenocarcinoma, and five as secondary carcinomas. Two cases of isolated metastasis of carcinoma to the ischium have been found in the literature. The first was described by Berg [3] that of a renal carcinoma with isolated metastasis to the ischium the second was that of an endometrial carcinoma of the uterine fundus described by H Milch and R. A. Milch.[44] In this later case the presenting symptom was that of sciatic pain and the patient was treated for almost a year under the mistaken diagnosis of "sciatica" resulting from a low back syndrome. The patient's low back syndrome was evidently atypical and x ray of the pelvis disclosed the true cause of her symptoms (Fig 94) As soon as the tumor was exposed it was evident that it was malignant and a wide resection of the ischium was undertaken. Microscopic section revealed a metastatic adenocarcinoma (Fig 95) Despite careful examination, no primary site could be determined until six months after operation when vaginal bleeding occurred. Curettage led to the diagnosis of a corpus carcinoma and a radical



FIG. 94 Metastatic uterine adenocarcinoma of the ischium. Endometrial carcinoma metastatic to the ischial tuberosity (Reproduced from Milch, H., and Milch, R. A., *A.M.A. Arch. Surg.* 66 686 1953.)



FIG. 95 Microscopic section of tumor in Figure 94



Fig. 96 Microscopic section of uterine corpus carcinoma (Reproduced Milch, H and Milch, R. A., *op cit*)

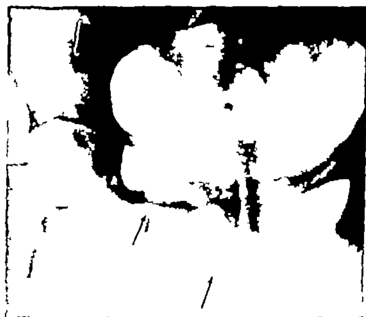


Fig. 97 Recurrent adenocarcinoma after resection of ischium in patient shown in Figure 94

hysterectomy was performed. Microscopic section confirmed the identity of the tumor with that of the metastatic ischial tumor (Fig 96) The patient remainded symptom free for about three years after the ischial resection, when she began to complain of pain in the pelvis. X rays at this time revealed recurrence in the pubis and the ilium (Fig 97)

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CHAPTER 15

Surgery of the Ischium

THE NECESSITY FOR surgical approach to all or a part of the ischium for diagnosis or definitive treatment arises in a number of different conditions. Strangely enough, practically no guidance on this subject is to be found in any of the standard surgical texts. Depending on the objective a variety of different approaches to the various parts of the ischium may be employed.

LOCALIZED AREAS

For simple surgical procedures confined to localized areas, direct intramuscular incisions have been used. They are best undertaken with the

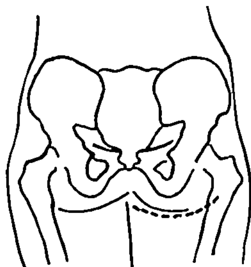


FIG. 98. The transverse incision is made directly in the gluteal fold.

patient in the prone position and with the lower extremities pendant over the edge of the table. The simplest is a small curved incision following the

lower margin of the gluteus maximus muscle (Fig 98) Lateral extension of this incision must be carefully gauged so as to avoid injury to the posterior femoral cutaneous nerve, which lies between the ischial tuberosity and the great trochanter to the inferior gluteal artery which lies at a somewhat deeper level and especially to the sciatic nerve, which lies still deeper and runs at right angles to the line of the incision.

EXTENDED AREAS

Where the condition under treatment may be expected to extend down the leg a longitudinal incision beginning at the upper edge of the ischial

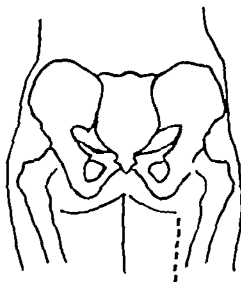


FIG. 99 The longitudinal incision is made midway between the ischial tuberosity and the great trochanter of the femur It parallels the course of the sciatic nerve and extends downward from the level of the gluteal fold.

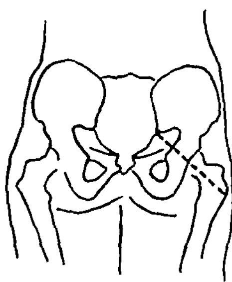


FIG. 100 The oblique incision for exposure of the ischial spine is made through the fibres of the gluteus maximus muscle at a slighter lower angle than Langenbeck's incision for exposure of the anterior gluteal artery

tuberosity and extending downward along the course of the hamstring muscles is preferable (Fig 99) No important vascular structures will be encountered in this approach and the sciatic nerve lies safely lateral to the skin incision.

To expose the sacrospinous ligament, the ischial spine, the gluteal or the pudendal vessels and nerves, the patient is placed on the unaffected side and an oblique muscle-splitting incision (Fig 100) of the type originally suggested by Langenbeck is made* It will be recalled that the superior gluteal artery and the suprapyriform fossa are to be located at the junction of the inner and middle thirds of a line drawn from the posterior superior spine of the ilium to the tip of the great trochanter while the hip joint lies at the

junction of the middle and outer thirds of this line (Fig 7) For exposure of the inferior gluteal artery the inferior pudendal vessels and nerves, and the base of the ischial spine an incision parallel to Langenbeck s but slightly more caudally placed should be made Since all these structures lie at the level of the mid point of a line drawn between the posterior superior spine of the ilium and the tuberosity of the ischium, the upper limit of these incisions should be continued downward and outward parallel to the line joining the trochanter and the iliac spine. The fibers of the gluteus maximus muscle are separated bluntly exposing the desired structures. When the necessity arises for reconstructive approach to the glenoidal margin, four different incisions may be employed (Fig 101) For exposure of the anterior

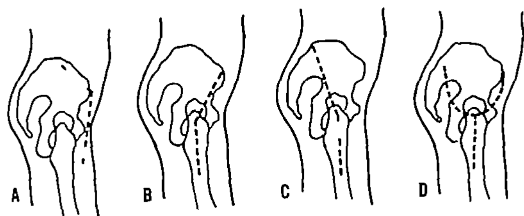


Fig. 101 Four incisions for approach to the acetabulum *A* the anterior iliofemoral (Smith-Petersen) *B* the lateral iliofemoral (Watson-Jones) *C* the posterior iliofemoral (Gibson) *D* the U or goblet-shaped incision (Murphy)

and superior margin the anterior iliofemoral incision (Fig 101*A*) the so-called Smith Petersen incision, is useful[14] This incision is an admitted modification of the incision originally described by Largi and subsequently modified by Langenbeck, later by Sprengel. It is hockey-stick shaped, runs along the anterior third of the iliac crest to the anterior superior iliac spine, and is then angled downward between the anterior border of the tensor fasciae femoris and the posterior border of the sartorius muscles The muscle flap including if necessary the anterior fibers of the gluteus medius muscle, is turned outward exposing the reflected head of the rectus femoris muscle which is divided and turned downward. This exposes the capsule of the hip joint particularly along its superior and anterior margins and affords easy access to the medial or pelvic surface of the os innominatum.

The lateral iliofemoral (Fig 101*B*) so-called Watson Jones incision[18] is a modification of an incision originally described by Richet[13] Beginning at or just below and behind the anterior superior spine of the ilium, the incision is carried down to the base of the great trochanter and is continued down

along the lateral aspect of the femur The fascia is incised in the same line, exposing the upper fibers of the vastus lateralis muscle. At the upper border of this muscle a small triangular space between the anterior edge of the gluteus medius muscle and the posterior fibers of the tensor fasciae femoris is opened and enlarged upward The gluteus medius and minimus muscles are retracted backward and the tensor fasciae femoris is retracted forward, exposing the superior and to a lesser degree, parts of the anterior and posterior margins of the acetabulum. Additional width can be obtained by freeing the attachment of the gluteus medius or the tensor fasciae femoris from the iliac crest.

For exposure of the posterior margin of the glenoid, the posterior iliofemoral, incision (Fig 101C) popularized by Gibson[3] has been described. This incision differs from the incision originally described by Kocher[4] in that exposure is made at the anterior margin of the gluteus maximus muscle rather than through its fibers. The incision is made from the posterior superior iliac spine to the base of the great trochanter and then down along the lateral aspect of the thigh. The fascia is incised in the same line the anterior border of the gluteus maximus muscle is defined, and the whole muscle is retracted backward. The gluteus medius and minimus muscles are retracted forward, if necessary after division of their attachment to the great trochanter This exposes the external rotators of the thigh—the pyriformis, the gemelli, and the obturator muscles—which are divided and retracted. The hip joint capsule and the posterior margin of the acetabulum can be readily visualized

For exposure of the entire glenoidal margin, the U-shaped incision originally described by Lexer is superior to either of the others (Fig 101*D*) The incision begins at the posterior iliac spine, curves downward and forward around the base of the trochanter and then upward and forward to the anterior spine of the ilium. After retraction of the skin and incision of the fascia, the borders of the gluteus medius muscle are outlined and the muscle is bluntly freed. The trochanter is then osteotomized at its base and the bone—with the attachment of the gluteus medius muscle—is elevated as a single flap exposing the capsule and the glenoidal margin throughout its entire extent. This incision was modified by *Murphy* [1] by the addition of a femoral extension converting the U into a goblet shaped incision.

Neither of the incisions thus far mentioned permits ready access to the ascending ramus of the ischium. McWhorter[7] found it necessary to devise such an approach for the treatment of an osteomyelitis in this area With the patient in the lithotomy position a transverse incision is made through the skin in the thigh extending from the middle of the gracilis to the middle of the adductor muscle. The adductor minimus muscle is split at about the middle of the distance between the gracilis and the adductor magnus muscle,

thus exposing the roof of the obturator fossa that covers a large part of the ramus of the pubis and the ischium.

Though McWhorter apparently contemplated the possibility of a perineal approach, he avoided it as too dangerous. On the contrary this approach

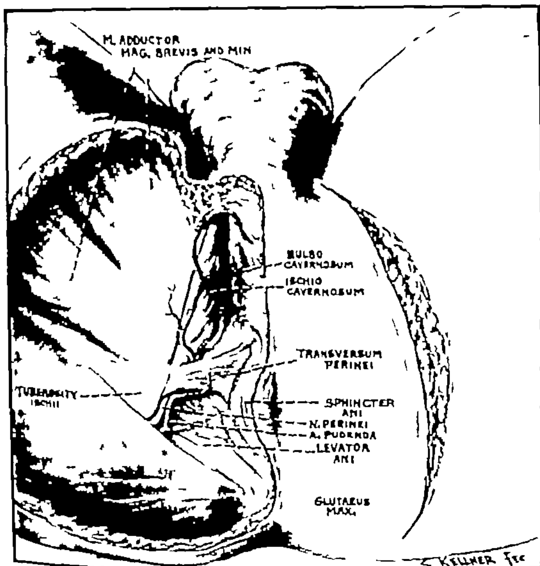


FIG. 10 Perineal incision for resection of the ischium (Milch) On the left the skin incision with the patient in the lithotomy is shown. On the right, the underlying structures are identified. (Reproduced from Milch, H., Partial resection of the ischium. *J Bone & Joint Surg* 17 166 1935)

appears to be the safest and most expeditious not only for exposure of the rami but also for more extensive procedures involving resection of almost all the ischium and the ramus of the pubis. It permits, additionally access to the intrapelvic as well as extrapelvic extension of the disease for which surgery is indicated When performed subperiosteally it permits operation without danger to the numerous anatomic structures in the region.

The operative technic first described by the writer in 1935[8,9] seems to be similar in principle if not in detail to an operation subsequently discovered to have been described by Bottini[3] in 1871 and by Aliloni[10] in 1888. It is to be noted that Bottini refers to earlier work by other authors, namely Regnoli, Erichsen, Velpeau (1836) and before him to Maunoir (1769).

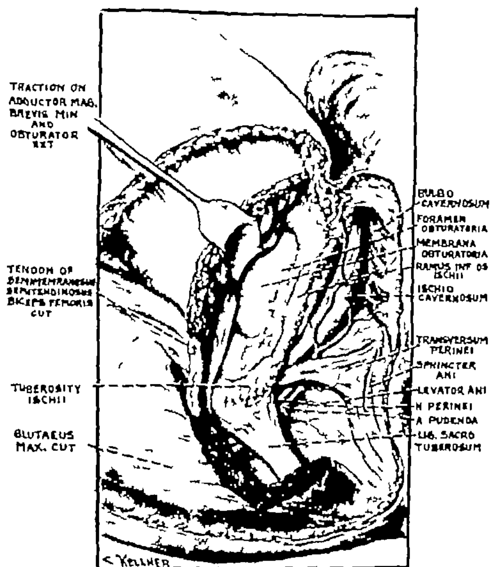


FIG. 103 The structures on the outer side of the ischium are freed subperiosteally exposing the bone and the obturator membrane (Reproduced from *J Bone & Joint Surg* op. cit)

The operation is most advantageously performed with the patient in the lithotomy position and with the buttocks elevated. If the lithotomy position is impossible, however because of fusion of the hips, the lateral position may be employed, with only slightly greater difficulty. The tuber ischii, the

inferior border of the body of the pubis, and the intervening rami are palpated. An incision is then made along this subcutaneous bony ridge and is continued for about three or four inches posteriorly in the skin covering the gluteus maximus muscle (Fig. 102). The lower edge of the gluteus is

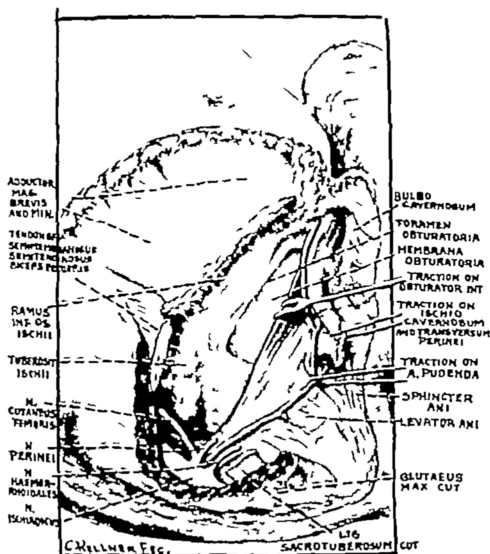


Fig. 104. The intrapelvic structures are freed subperiosteally exposing the obturator membrane and the inner side of the bone from the symphysis pubis to just below the ischial spine. (Reproduced from *J. Bone & Joint Surg., op. cit.*)

defined and elevated with the finger so that the fibers that overhang the tuber ischii may be cut across, exposing the tuberosity of the ischium, with the attachment of the hamstring muscles and the sacrotuberous ligament along its inner border. At this margin between the two last mentioned structures, the periosteum over the tuber ischii is incised. By a subperiosteal

dissection, the hamstring muscles are detached and displaced laterally The periosteal incision is then carried forward along the rami of the ischium and pubis in the line of separation between the adductor muscles laterally and the perineal structures medially As the procedure is carried forward, the adductor magnus is separated and displaced laterally until the lower external portion of the bone is exposed Proceeding deeper into the wound, the adductors, *quadratus, brevis and longus and, finally* the obturator externus are separated exposing the lower rim of the obturator foramen, and



FIG. 105 The extent of bone that may be resected is indicated. (Reproduced from *J Bone & Joint Surg op cit.*)

displaced outward in one large flap that contains the sciatic nerve (Fig 103) During the course of this dissection no important structures are met and no serious hemorrhage need be feared

The exposure of the medial wall is rendered only slightly more hazardous by the presence of the internal pudendal vessels. However if after separating the superficial structures, the ischiocavernosus and transversus perineal muscles, the dissection is kept strictly subperiosteal, the pudendal nerve and vessels will be elevated without any danger and the lower fibers of the obturator internus will be exposed in the depths of the wound (Fig 104) These can now be raised, freeing the whole of the lower margin of the

obturator foramen. In the posterior part of the incision, the attachment of the sacrotuberous ligament is then sharply cut away and the lesser sacrosciatic foramen is opened. Here care must be exercised to avoid injury to the pudendal vessels as they wind around the spine of the ischium. With caution, they may be subperiosteally freed and displaced off the spine so that the resection may be carried out to or above the level of the spine (Fig 105). The area to be resected is then clearly exposed. A Gigli saw is passed through the obturator foramen and the pubic ramus is cut across. With the



Fig. 106. Roentgen appearance of the right half of the pelvis after resection of the ischium for tuberculosis.

saw or an osteotome the descending ramus is cut. All the ischium below the level of the spinous process as well as the descending ramus of the pubis may easily be removed through this incision (Fig 106).

For the resection of less than the whole bone an aliquot portion of the incision may be used. Despite the fact that the incision is made through the potentially infected region of the perineum healing by primary intention usually occurs. In clean cases, layer closure should be made. In infected cases, dependent drainage is available through the posterior part of the incision. This type of resection, modified only in the respect that the approach to the bone is made through the grossly ulcerated area, is employed in the modern treatment of ischial pressure sores.

For primary malignant tumors of the ischium, hemipelvectomy [1, 2] that

permits of much wider excision is to be preferred to radical resection of the ischium, which is thoroughly satisfactory for most other conditions requiring ischiectomy

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